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Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

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OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

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Abstracts.

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SESSION OF 1930-31
(Vol. XVIII, Part I)

STUDIES ON ANHYDRIDE — ALDEHYDE — ESTER SYSTEMS; THE RATE OF FORMATION OF BUTYLIDENE DIACETATE.

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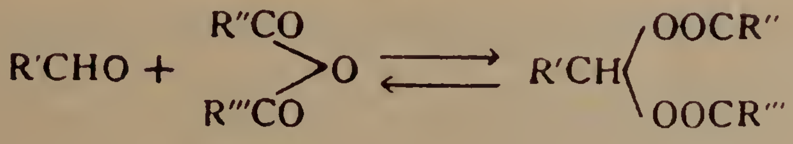
(Received September 26, 1931).

ABSTRACT.

The series of liquid phase reactions represented by the general equation



$$R'CHO + \begin{matrix}R''CO\\ \\ R'''CO\end{matrix}\!>\!O \rightleftharpoons R'CH\!<\!\begin{matrix}OOCR''\\ \\ OOCR'''\end{matrix}$$

has been found to be very suitable for the test of previously outlined ideas regarding the effect of molecular attractive forces on the velocity of chemical change. This paper deals with the uncatalysed reaction in the liquid state between acetic anhydride and butyraldehyde to form butylidene diacetate. The reaction velocity and the equilibrium concentrations have been determined by a "bulb method" for equimolecular mixtures from 138 to 180°. The reaction is proved to be strictly homogeneous, reversible and free from side reactions. It is catalysed by traces of mineral acids and by acetic acid at concentrations above about 2% so that the materials must be carefully purified and the apparatus thoroughly cleaned in order to obtain reproducible results. The freezing point curve of the system shows the existence of a highly associated 1:1 molecular compound melting at —20°. The existence of this compound at higher temperatures is indicated by the fact that at 20° there is a large negative heat of mixing although the chemical reaction itself is exothermic. No measurable reaction occurs after 6 months at room temperature. The significance of the results are discussed and the scope of future work in this connection is indicated.

Introduction.

During the past few years O. Maass and his students have collected a considerable amount of experimental data indicating that the physical forces of attraction between molecules play a large part in determining the velocity of chemical reactions and suggesting that in general the explanation of the highly specific nature of reaction rate is to be looked for in mechanisms involving the interplay of such molecular attractive forces.[1] As the effect of these forces on the physical properties of a system increases with the total concentration it is to be expected that their influence on reaction velocity will likewise increase with concentration and so be most readily observed in reactions in liquids and highly compressed gases. An example will facilitate the presentation of the ideas underlying the experimental work in this connection and will serve to indicate the nature of the effects to be expected.

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*By vote of the Council, the Transactions have been discontinued.

In an apparently homogeneous liquid mixture of two potentially reactive molecules A and B there exist three attractive forces, viz., A to A, B to B, and A to B. If either of the first two is greater than the third, then at any point the actual composition of the solution may be far from that indicated by its analysis or preparation and the velocity constant of the reaction will be diminished since the acquisition of activation energy by a molecule surrounded only by its own kind cannot result in reaction. On the other hand if the attraction between A and B predominates the solution will be more truly homogeneous and the concentration will be more uniformly equimolecular with the obvious result that the velocity of the reaction will be increased since the chances are that a greater proportion of the molecules in possession of energy of activation will be spatially in positions favorable for reaction.

Where the forces A to A or B to B are very large compared to the force A to B, like molecules will associate to an extent sufficient to "squeeze out" unlike molecules and the system will separate into two layers, i.e., the rate of the homogeneous reaction will be zero. Where the attraction A to B is large enough to form a highly associated molecular compound the great majority of the molecules can be considered as being involved in "perpetual collisions" and the rate of reaction will be determined solely by the rate of activation. Between these two extremes every gradation is possible and a quantitative investigation of the actual part played by such forces in determining reaction velocity necessitates some measure of their magnitude.

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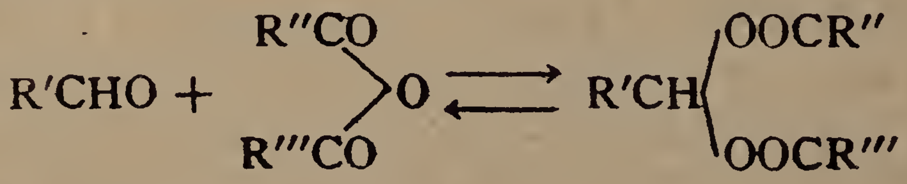
[1] For bibliography, etc. see Coffin and Maass, *J. Am. Chem. Soc.*, **50**, 1427, (1928); *Can. J. of Research* **3**,526 (1930); **3**,540, (1930).

While Van der Waals "a" is theoretically the most direct measure of the forces of attraction between like molecules its determination is difficult and its meaning is obscure in the case of liquid mixtures. A more convenient but strictly relative estimate of the forces between the molecules of, for instance, two different series of compounds is afforded by a comparison of those physical properties of the pure substances and their mixtures which according to kinetic theory are the consequences of intra molecular attraction. For example from the complete freezing point diagram of a two component system (usually to be obtained at temperatures so low that the velocity of the chemical reaction is negligible) the extent of association or dissociation of one substance in the other as well as the occurrence composition and comparative stability of molecular compounds can be determined. Thus from the freezing point and reaction velocity curves for mixtures of different members of two series of compounds any parallelism between molecular attractive forces and reaction rate may be noted. For the interpretation and the general theoretical significance of any such parallelism it is highly desirable to be able to determine the order and probable mechanism of the reaction.

So unsuitable is the vast majority of chemical reactions for profitable quantitative study in this connection that one of the most important parts of such an investigation is the choice of the system on which to work. That is, the reaction to be studied must possess certain simplifying "ideal" characteristics if velocity and equilibrium data of any real theoretical value are to be obtained. It must of course proceed at a measurable and reproducible velocity under experimentally attainable conditions of temperature and pressure and be of such a nature that its progress may be readily followed and its equilibrium concentrations determined. It should be simple, uncatalysed, strictly homogeneous and free from complicating side reactions over a wide range of temperature and concentration in both the liquid and gaseous states. A further necessary feature and one practically confined to organic reactions is that the character of the reaction should remain unchanged throughout a series of compounds so that various molecular attractive forces, which can be changed only by changing molecular structure, may be obtained.

The formation of esters from aldehydes and acid anhydrides according to the equation



$$R'CHO + \begin{matrix}R''CO\\ \\ R'''CO\end{matrix}\!\!>O \rightleftharpoons R'CH\!\!<\!\begin{matrix}OOCR''\\ \\ OOCR'''\end{matrix}$$

has been found to satisfy the above criteria remarkably well. The reactions so far investigated are strictly homogeneous and take place at a reproducible and measurable velocity in the absence of catalysts over a wide temperature range in both the liquid and gaseous states. Except at high temperatures in the gaseous state no side reaction occurs so that the determination of only one component (the anhydride analysis is most convenient) is necessary to completely define the concentration of the system. In the liquid phase the equilibrium does not in general lie too far to any one side and experimentally may be approached from either direction. In the gaseous state the equilibrium as written above appears to be shifted completely to the left at all temperatures—a result of considerable significance from several points of view. These gaseous ester decompositions, which are homogeneous and monomolecular,[2] are being discussed in a series of papers in the "Canadian Journal of Research". As far as physical properties are concerned preliminary experiments on several different aldehyde-anhydride systems indicate that highly associated 1:1 molecular compounds exist at low temperatures and that a relative estimate of the "A to B" attraction at higher temperatures can be obtained from the heats of mixing which are negative and of the order of several hundred calories per mol.

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[2] Coffin, *J. Am. Chem. Soc.*, **53**, 3905, (1931).

The present paper deals with the velocity of the reaction in the liquid state between equimolecular quantities of butyraldehyde and acetic anhydride to form butylidene diacetate.

EXPERIMENTAL.

Velocity Measurements. The velocity of the reaction was determined by heating known weights of an equimolecular mixture of aldehyde and anhydride at definite temperatures for various lengths of time and analysing for unreacted anhydride. Since the vapor pressure of the mixture is considerable at temperatures at which the reaction attains a measurable rate all experiments were carried out in sealed pyrex glass tubes which were made large enough to contain about 1 gram of the mixture in order that analytical errors would not be augmented by the use of too small a quantity of material. These tubes were simply 10 cm. lengths of 5 mm. i.d. tubing drawn down at each end to a heavy capillary ending in a bell mouth to which rubber pressure tubing could be attached for filling and evacuating. They were cleaned with hot chromic acid solution, thoroughly dried, labeled with turns of aluminium wire and weighed. One end of the tube was then immersed in a freshly prepared and analysed reaction mixture and the liquid was drawn up into it by suction at the other end which was then sealed off. The tube was then inverted in a solid CO_2 ether mixture and as soon as the contents had frozen was evacuated through the remaining capillary which was likewise sealed off. A second weighing of the tube plus the two sealed off ends gave the weight of the mixture taken. Care was taken throughout the manipulation to prevent the loss of either component by evaporation and to protect the mixtures from contact with the moisture of the air—a very necessary precaution in experiments involving acetic anhydride. In filling each tube an effort was made to take a quantity of the mixture such that the tube would be very nearly full of liquid at the temperature of the experiment in order that complications due to a different equilibrium or reaction velocity in the gaseous phase would not occur. After a little practice it was easy to estimate this quantity quite closely. As preliminary experiments had proved that the reaction velocity at room temperature was negligible the filled bulbs could be kept indefinitely and the rate measurements and analyses carried out at leisure.

In the actual experiments, which were always carried through in duplicate, the filled tubes bound in pairs to glass rods were plunged into a thermostat at the desired temperature. From time to time a pair was removed and quickly cooled in running water. The tip of each capillary was then cut off and the tube contents was carefully washed with a large quantity of distilled water into a flask for analysis. After standing for half an hour (to allow the anhydride to reach equilibrum with the water) the free acid was titrated with standard baryta in the presence of phenolphthalein. From this figure the amount of anhydride reacted (= amount of aldehyde reacted = amount of ester formed) was calculated.

The homogeneity of the reaction was tested by carrying out several experiments exactly as described above except that the glass surface in contact with the liquid was enormously increased by loosely filling the tubes with finely crushed pyrex glass. As pointed out below the fact that the rate remained unchanged proves that the reaction takes place homogeneously throughout the liquid. It is worth emphasizing that all the reactions took place in the liquid phase only and in the absence of air, moisture, and catalysts.

Except at 138°, where a xylene vapour bath was used, constant temperatures were obtained by means of an electrically heated and vigorously stirred oil bath provided with a bimetallic thermoregulator. By continually tapping the regulator with a device actuated by the stirring motor the temperature could be kept constant within about 0.2° for many hours at a time. Temperatures were measured on a mercury thermometer graduated in 0.2° and calibrated against Reichenstalt standards.

Analyses. As already stated the contents of the reaction tubes were analysed by allowing the anhydride to react with a large excess of water and titrating the acetic acid formed with standard baryta. In determining the amount of acetic acid in the reaction mixtures and in the original anhydride recourse was had to the well known analine method of Menschutkin in which the anhydride present reacts with the dry analine to form equimolecular quantities of acetanalide and acetic acid the latter of which can then be titrated with alkali to obtain half the anhydride plus the acid originally present. From these data together with the figure for all the anhydride plus the acid the amount of each in the original sample can be calculated. The same baryta solution was used throughout, a 10 l. lot having been made up and standardized at the beginning of the work. Its concentration (0.284N) was checked from time to time.

In order to obtain definite proof that the ester formed was equivalent to the anhydride lost many attempts were made to devise a saponification procedure by which the amount of ester present could be determined. As it was at length evident that the erratic results first obtained were in all probability due to the absorption of caustic by the resinification of the liberated butyraldehyde the final saponifications were carried out in low wide mouthed glass jars kept in a water bath at temperatures somewhat above the boiling point of butyraldehyde. Small quantities of alkali were run in from a burette from time to time until the smallest possible excess had been added. After cooling to room temperature the excess alkali was titrated with standard HCl. This method though tedious gives quite good results presumably on account of the fact that the butyraldehyde can escape from the solution as it is liberated and is not at any time in the presence of a large excess of caustic.

Purification of Materials. The butyraldehyde (Eastman's C. P.) was dried for several weeks over a large quantity of $CaCl_2$ from which it was removed by distillation on a water bath. It was then fractionated twice through a 4 foot glass column and the middle third used for the velocity experiments.

Several kilograms of 85% acetic anhydride (Eastman's Technical) was repeatedly fractionated through a large glass column of special design until the acetic acid content was reduced to about 1%. A few hours' refluxing with a large excess of metallic sodium and a final fractionation gave a very pure sample of anhydride.[3]

Pure butylidene diacetate was prepared by refluxing equimolecular quantities of butyraldehyde and acetic anhydride with about 0.1% sulphuric acid as catalyst. When after several hours the boiling point had become constant (140° at 760 mm.) the catalyst was neutralized with a calculated excess of sodium acetate and the whole was fractionated several times in vacuo. The final ester fraction was washed with dilute $Ba(OH)_2$ solution until free from acid, dried with $CaCl_2$ and again fractionated. Saponifications, carried out as described above, as well as cryoscopic molecular weight determinations in benzene proved beyond all doubt that the compound formed was butylidene diacetate. That it was of a high degree of purity was indicated by the constancy of the physical properties of the fractions obtained in the final distillation. The following physical constants were determined.

B. P.	760 mm.	195°
B. P.	2 mm.	90°
M. P.		—6.5°

RESULTS.

In Figure I are plotted the experimental results at 160° (curve B.○●⊕) and 180° (curve A△). As is to be expected equilibrium is reached more rapidly at the higher temperature and corresponds to an ester concentration of 24 mole % at 180° as against 28 mole % at 160°. Thus rise of temperature shifts the equilibrium in the direction of ester decomposition in accordance with the fact that the latter is the endothermic reaction. The "time to half value" at 160° is seen to be approximately 8 hours as compared with 3 hours at 180°.

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[3] Edwards and Orton. *J. Chem. Soc.*, **99**, 1181, (1911).

The open circles of curve B were obtained with reaction mixtures made from anhydride containing 0.6% acetic acid while the solid circles represent experiments in which the original anhydride analysed 2% acid. It is to be noted that both sets of points fall fairly well on the same curve showing that acetic acid at these low concentrations exerts no appreciable catalytic effect. That such is not the case at higher concentrations of acetic acid was evinced by a series of experiments (not plotted in Figure I) made with anhydride containing 5% acid. The curve obtained in this case leads to the same equilibrium concentrations but the reaction velocity is much increased, the "time to half value" being 4 hours as compared with the 8 hours of curve B. Curve A was obtained from anhydride analysing 0.6% acid and is therefore directly comparable to curve B. At 138° the "time to half value" for mixtures made from anhydride containing 5% acetic acid is about 20 hours.

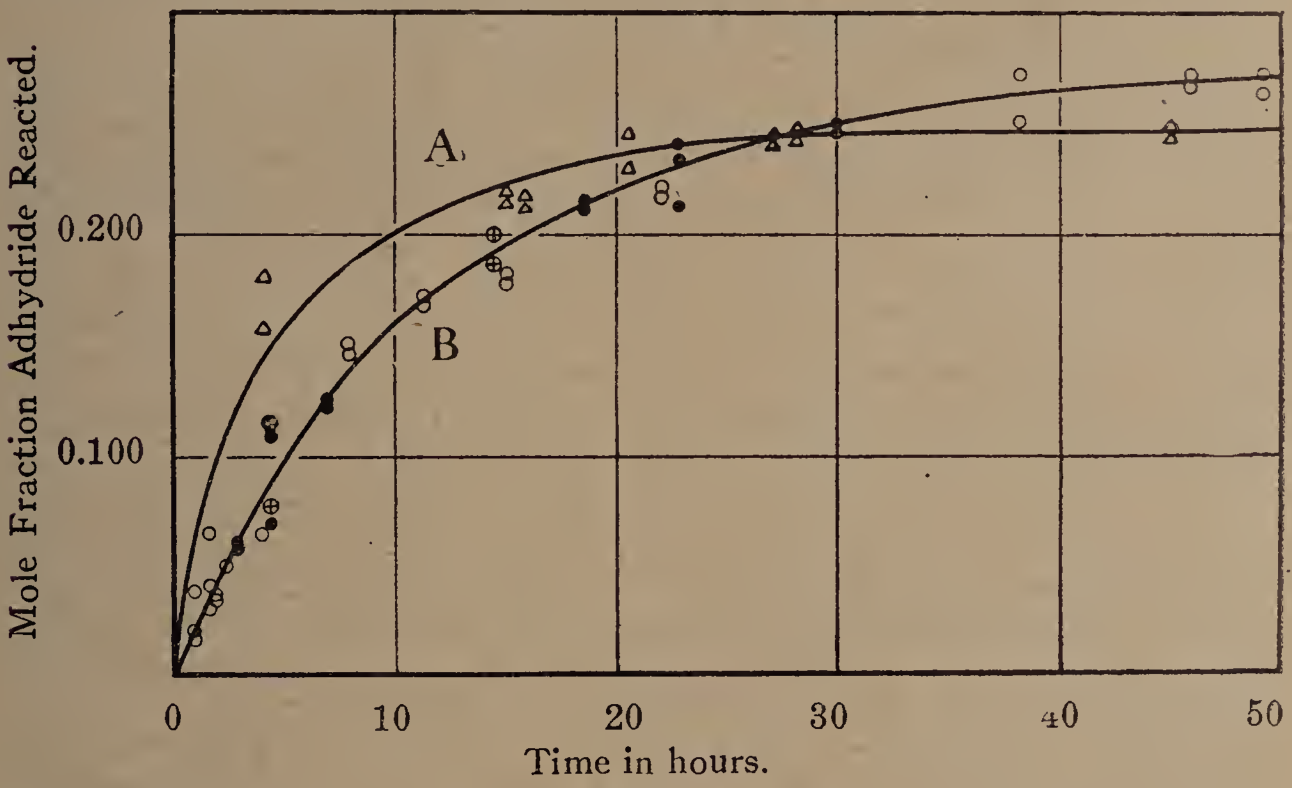

Fig. I.

The points ⊕ of curve B were obtained with the bulbs in which the glass surface in contact with the reaction mixture was increased by the addition of powdered glass. The reaction is seen to be definitely homogeneous, no increase of rate being evident in these experiments.

The reality of the equilibrium was definitely established by experiments in which it was found that the same final concentrations could be reached from either side. Thus after a few hours' refluxing with 0.1% H_2SO_4 an equimolecular mixture of aldehyde and anhydride was indistinguishable as regards both analyses and physical properties from a quantity of ester given the same treatment. At atmospheric pressure the final temperature in each case was 140° at which the ester concentration was 35 mole % When no catalyst was employed about a week's refluxing was necessary to reach equilibrium.

Application of the van't Hoff isochore to the three equilibrium points obtained gives a heat of reaction of about 6,400 cal. per mole of ester formed and indicates that the latter under equilibrium conditions is about 80% dissociated at 195° where ordinarily it distils unchanged. Experiments to be reported in detail elsewhere have shown that in the gaseous state at 210° dissociation is practically complete. It would seem therefore that change of state has but little effect on the equilibrium.

A pronounced maximum in the freezing point curve of the system indicates the existence of a highly associated 1:1 molecular compound the melting point of which is -20°,—50° higher than that of the anhydride and 80° higher than that of the aldehyde. That such "A to B" attraction is appreciable at still higher temperatures is shown by the fact that while both liquids are of the normal unassociated type their heat of mixing has a negative value of several hundred calories per mole at 20°. The vapour pressure curves of the mixtures are likewise highly abnormal and give promise of affording convenient comparisons of the molecular forces involved in the various aldehyde anhydride systems.

That a measurable homogeneous reaction does take place in the liquid state between molecules which exhibit an attraction of the order indicated in the preceding paragraph is qualitatively in harmony with the ideas outlined in the above introduction. Any quantitative conclusions must await the investigation of other aldehyde anhydride systems.

THE DETECTION OF METHANOL IN THE PRESENCE OF ETHYL ALCOHOL.

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Dept. of Chemistry, Dalhousie Univ., Halifax, N. S.

(Received December 24, 1931).

ABSTRACT.

By interaction with hydriodic acid, the alcohols are converted into iodides which are distilled into a solution of trimethyl amine in absolute alcohol and there converted into the corresponding quaternary ammonium derivatives. The precipitation of the very sparingly soluble tetramethyl ammonium iodide indicates the presence of methanol in the original sample provided other methoxy compounds are absent. This method allows the detection of 0.1% methanol in a 1 c.c. sample or of 0.2% methanol in a 0.1 c.c. sample. A wide range of alcoholic beverages gave negative tests for methanol as also did formaldehyde and higher alcohols.

Procedure.

One c.c. of the sample and 5 c.c. of constant boiling hydriodic acid are pipetted into an 18x150 mm. pyrex test tube and a small piece of tin foil added. The test tube is closed with a rubber stopper through which extends a glass tube bent at a right angle. The contents are heated to gentle boiling over a small flame, and the vapors absorbed in 10 c.c. of a 10% solution of trimethyl amine in absolute alcohol. Care is taken that hydriodic acid is not driven over and that the trimethyl amine solution is not sucked back. A white, granular precipitate indicates the presence of methanol in the sample.

Notes.

1. This is a modification of Willstätter and Utzinger's method[1] for the determination of methoxy and ethoxy groups. The hydriodic acid reacts with the alcohols to form the corresponding alkyl iodides which are distilled into the solution of trimethyl amine in absolute alcohol. Here tetramethyl ammonium iodide and trimethyl ethyl ammonium iodide are

---

[1] Willstätter and Utzinger, *Ann. d. Chem.*, **382**, 148-50 (1911).

produced. The former is very insoluble in absolute alcohol and comes down as a white, granular precipitate. The latter is much more soluble and crystallizes in needles.

$$CH_3OH + HI = CH_3I + H_2O$$
$$C_2H_5OH + HI = C_2H_5I + H_2O$$
$$CH_3I + (CH_3)_3N = (CH_3)_4NI$$
$$C_2H_5I + (CH_3)_3N = (CH_3)_3(C_2H_5)NI$$

2. The hydriodic acid is prepared by dropping water onto phosphorus pentiodide (red phosphorus and a slight excess of iodine) and absorbing the hydrogen iodide in water. No phosphine is formed when iodine is in excess. The dilute solution is fractionated, and the constant boiling fraction (125-126°) is collected and stored in small amber, glass-stoppered bottles.

3. In each test one piece of tin foil 0.5 sq. cm. in area and weighing approximately 20 mg. is amply sufficient. Its role is to prevent bumping.

4. The trimethyl amine solution is prepared from paraformaldehyde and ammonium chloride by the method of Adams and Brown[2]. Less odour escapes if the coil condenser and absorbent alcohol are cooled with a solid carbon dioxide and alcohol mixture, and if, after completion of the preparation, the last traces of the amine are removed by attaching the exit to the condenser to a water pump.

5. Starting with a 1 c. c. sample of mixed methyl and ethyl alcohols, the presence of 1% or more of methanol is indicated by a fine, granular precipitate in less than 1 minute; 0.1% of methanol yields a precipitate in less than half an hour; and 0.05% of methanol, no precipitate. When very slight, this precipitate can be seen best in the sunlight as shining particles. The precipitate is always granular. On long standing needles of trimethyl ethyl ammonium iodide may form, especially if the temperature is below 20°C. They redissolve when gently warmed.

---

[2] Adams and Brown, "*Organic Syntheses*," John Wiley and Sons, New York. **1921**, vol. 1, pp. 75-78.

6. The method as outlined can be modified to detect methanol in samples smaller than 1 c.c. One-tenth c.c. of the sample, 0.5 c.c. of constant boiling hydriodic acid and a minute piece of tin foil are heated in a 15x100 mm. pyrex test tube and the iodides absorbed in 1.0 c.c. of a 10% solution of trimethyl amine in absolute alcohol. Then 0.2% of methanol in ethyl alcohol yields a precipitate within 2 minutes, while 0.1% methanol gives no positive result. 0.2% methanol in a 0.1 c.c. sample corresponds to 0.15 mg. of methanol.

7. The presence of ethyl alcohol increases the sensitivity of the test. One c.c. of a 0.1% solution of methanol in water gives a negative result whereas 1 c.c. of a 1% solution of methanol in water gives a heavy precipitate in less than a minute. It is probable that in the distillation the ethyl iodide helps to drive over traces of methyl iodide.

8. Gin, whiskey, brandy, rum, Italian vermouth, sherry and port have been tested for methanol with negative results. It is a surprising and useful fact that formaldehyde (and paraformaldehyde) gives a negative test. Likewise do the higher alcohols. Oil of wintergreen (methyl salicylate), as well as other compounds containing methoxy groups, gives a positive test. Hydriodic acid in relatively large amounts gives a precipitate of trimethyl ammonium iodide, therefore care must be taken that the heating be not too strong or prolonged.

9. The effect of replacing the reagents with closely related substances has been investigated. When hydrobromic acid is substituted for hydriodic, the test is less sensitive for 1 c.c. of 2% methanol in ethyl alcohol gives a precipitate after 15 minutes while 1% methanol gives no precipitate. The replacement of trimethyl amine by dimethyl aniline is not satisfactory and the use of commercial 90%, instead of absolute, alcohol in the amine solution is not recommended.

10. The estimation of methanol in the presence of ethyl alcohol will be dealt with in a further paper.

PRESIDENTIAL ADDRESS.

Douglas McIntosh.

(Read at the Annual Meeting, October 15, 1931).

While custom has made an address from the retiring President a duty, our constitution views the opportunity as a privilege which a retiring officer has earned by the interest he has shown in the society; and so I regard it. With this in mind, I ask your indulgence while I review briefly the events of the past year. It is with regret that I end the pleasant relationship with this society, its council and members, and this regret is increased by my inability to meet with you this evening.

It was my sad duty to refer to the deaths of two of our members on the occasion of our first meeting last year. To-night, I must speak of the passing in August, 1930 of a member well known to many of us. William F. McKnight, B.Sc., Professor of Electrical Engineering at the N. S. Technical College for many years, has made for himself a place in the teaching profession and in technical science, which is being widened and deepened by the growing reputations of his students. An able scientist, he preserved an equitable balance between his scientific and his civic and social duties. Prof. McKnight served on the council of this society for the year 1928-9. Latterly, due to ill health, he was seldom seen at our meetings. In his brave struggle with a dread disease he went down with colours flying. His death is regretted by all who had the privilege of his acquaintance.

Seven general meetings for the reading of papers were held during the year. Our programme was exceptionally full, and the discussions were interesting and inspiring. The papers may be roughly classified: 8 in physics, 7 in chemistry and bio-chemistry; 3 in zoology, 3 in pharmacology and 1 in geology. Probably the meeting at which the greatest interest was shown was that at which an account of the earthquake of November 18, 1929, was given by the Professors of Physics and Geology of Dalhousie University; and the facts collected, to be published in our transactions, will be a more complete record of this great disturbance that has yet appeared in print. Five demonstrations of new apparatus or new scientific methods were given during the session.

Regret was expressed by one of our oldest members that so few papers dealing with the natural history of the province had been read during the last few years. This is the fault, not of the officers or council, but of our naturalists. It is hardly necessary to say that contributions from them will be welcomed in the same spirit as those received from our physicists or chemists.

The appearance of our Transactions for 1928-29 was somewhat delayed due to circumstances familiar to all of you. Those for 1929-30 will appear shortly. Let me take this opportunity of congratulating Prof. King, our editor, on his work, and in the name of the society thanking him and the other members of the committee for the time they have so generously given us.

Our notices are now sent out in a way which should eliminate all omissions, so that no member should fail in his attendance at meetings through lack of knowledge.

The Government grant has been continued and our finances are in satisfactory state. This will be gone into fully by our treasurer.

Our library has been added to both by exchanges and by the expenditure of the Government grant. Mr. Piers will tell you of its condition in his report.

Two years ago a science exhibition was held in the buildings of Dalhousie University. It would be out of place for one who will be unable to take part in the work necessitated by such an undertaking, to offer advice on future displays. In view of the interest taken by the citizens of Halifax, the members of the society should not let time pass without discussing this question.

Of recent years, the retiring President has not, as a rule, been elected to the council, and the society loses his assistance and advice. This I believe is a mistake. I feel that it would be a good measure to revise our constitution and make the past president an ex-officio member of council.

Our society has lost several members through resignation from the Experimental Station for Fisheries and from Dalhousie. May we hope that the loss to the Institute will be more than made up by the young and energetic men who are filling these vacancies.

The handsome piece of plate, which we had hoped to present to our most distinguished member at a dinner in his honour, has been engraved and will be given to his family. It bears the following inscription:

> Presented to
> Alexander Howard MacKay, Esq., LL.D., F.R.S.C.
> by
> The Nova Scotian Institute of Science
> on the 11th of May, 1929,
> as a token of deep respect and in recognition
> of his long and eminent service in the cause
> of Science and Education.

May I thank the members for the aid they have given and the forbearance they have shown to the officers and members of the Council. I ask for a continuance of their kindness to the officers elected this evening.

THE RESPONSE OF INVOLUNTARY MUSCLE TO PITUITRIN, MORPHINE AND QUININE. N. B. Dreyer, Dept. of Pharmacology, Dalhousie Univ., Halifax, N. S. (Read May 11, 1931). On the intestines, morphine (.1-.5 mg. per kg.) produces an increase of tone and movements. Peristalses become more frequent. The tonic effect passes off somewhat earlier than the motor effect. On the non-pregnant uterus morphine and quinine have no demonstrable effect on motility; on the pregnant uterus morphine occasionally produced a complete inhibition of movements. In many cases the rhythm was uneffected. On the involuting uterus forty-eight hours post partum, no change was observed. In this uterus adrenaline produces an inhibition of movements. The stimulant action of morphine seen in the intestine is absent in the uterus.

Quinine sometimes shows slight stimulation on the early pregnant uterus but this stimulation was transitory. In the involuting uterus quinine has no effect. In the intestine quinine heightens the tone and increases the movements slightly in doses of 2 mg. per kg. In doses of 4 mg. per kg. there is an appreciable increase in the amplitude of the movements.

Pituitary extract shows a brief stimulation on the intestine followed by an inhibition of several minutes. This is followed by a return of tone above normal, and an increase in the amplitude of movements. Pitressin behaves like crude pituitary extract. Pitocin produces a pure inhibition on the intestine. The effects on the uterus were those usually described for these two constituents.

PROCEEDINGS OF MEETINGS.

SESSION OF 1930-31.

(*All meetings were held in the Medical Science Building, Halifax*).

69*th Annual Business Meeting, Oct.* 15, 1930.—The First Vice-President, Dr. E. G. Young, in the chair. Others present: Prof. D. S. McIntosh, D. J. Matheson, Dr. H. R. Chipman Dr. H. S. King, Prof. G. A. Burbidge, Capt. W. F. Mitchell, Dr. H. L. Bronson, Prof. C. B. Nickerson, Dr. J. H. L. Johnstone, Prof. E. Hess and H. Piers.

In the absence of the President his address was read by Mr. Piers. The Treasurer's report showed that the receipts for the past year were $2,033.66; expenditures, $623.43; balance in current account, $1,410.23; reserve fund, $212.48; and permanent endowment fund, $1,500.00—The Librarian's report showed that during the year ended Sept. 30, 1930, 1,827 books and pamphlets had been received through the Institute's exchange-list; and the total number in its library at that date was 19,237. The number of accessions of the entire Provincial Science Library (with which that of the society is incorporated) in the same period was 2,149; and the total number in the Library on Sept. 30, 1930, was 80,311. During the year 144 books were borrowed. In response to a request from the Council of the Institute, the Governor in Council on March 18, 1930 appointed Dr. F. H. Sexton and H. Piers, and on recommendation of the Institute, Dr. E. G. Young and Dr. J. H. L. Johnstone, to be members of a Commission to administer the Provincial Science Library of Nova Scotia, to hold office for one year. The Commission held its first meeting on April 16. —Reports were also made by the Corresponding Secretary and the Editor of the Transactions.

It was resolved that the Insitute learns with deep regret of the death of its member, William Falconer McKnight, B.Sc., A.M.E.I.C., professor of electrical engineering at the N. S. Technical College, which occurred at Riverglade, N. B., on Aug. 25th., at the age of forty-six years, and desires to express its deep sympathy with his widow in her sad bereavement.

It was resolved that students registered in any educational institution be allowed to join the Institute as student members, with a fee of one dollar, but without a vote.

The following were elected officers for the year 1930-31:

President,—Prof. E. G. Young, Ph.D.; *vice-presidents*,—Prof. D. S. McIntosh, M. Sc., Prof. A. H. Leim, Ph. D.; *treasurer*,—D. J. Matheson, B.Sc.; *corresponding secretary*,—H. R. Chipman, Ph.D.; *recording secretary and librarian*, Harry Piers; *councillors without office*,—Prof. H. S. King, Ph.D., Prof. G. A. Burbidge, Prof. G. H. Henderson, Ph.D., D. J. Mackenzie, M.D., Rev. Bro. W. Cornelia and Prof. H. P. Bell, Ph.D.; *auditors*,—P. R. Colpitt and Prof. W. P. Copp, B.Sc.,

A vote of thanks was passed to the retiring president, Dr. D. McIntosh, who had removed from Halifax.

1*st Ordinary Meeting, Nov.* 17, 1930.—It was announced that on Nov. 3 the following had been elected ordinary members: Dr. C. C. Coffin, Dr. D. Mainland, Dr. N. B. Dreyer, and Dr. R. F. Ross.—Dr. E. G. Young read a paper on "An Analysis of Fox Milk," and Dr. G. H. Henderson and J. L. Nickerson one on "The Ranges of Alpha Particles from Thorium."

2*nd Meeting, Dec.* 8, 1930.—It was announced that on Nov. 24, Dr. F. R. Hayes, Dr. E. R. Jones and Miss C. I. MacFarlane had been elected ordinary members; Prof. R. M. Fisher and Prof. H. W. Harkness, associate members; and eleven others as student members.—Dr. N. B. Dreyer presented a paper on "Some Effects of Opium Alkaloids on the Intestines of Different Animals."

3*rd Meeting, Jan.* 12, 1931.—It was announced that seven student members had been elected on Dec. 28—Dr. E. R. Jones presented a paper on "Intranuclear Deutoplasm in the Turbellarian *Prorhynchus applanatus*," and Dr. F. R. Hayes one on "The Physiological Response of Paramaecium to Sea-water."

4*th Meeting, Feb.* 9, 1931.—It was announced that Prof. D. G. Macgregor, Sackville, N. B., had been elected an associate member on Jan 26. The following papers were presented: "High Acidity of Quarry Water," by S. A. Beatty and Dr. A. H. Leim; "Some Actions of Mercury Salts on the Intestine," by Dr. N. B. Dreyer; and "The Polysaccharide of *Chondrus crispus*," by Dr. E. G. Young and Miss M. R. Butler.

5*th Meeting, Mar.* 9, 1931.—It was announced that three student members had been elected on Mar. 2. A minute of the Council meeting of Jan. 26, with reference to changes in the title, contents and arrangement of the Institute's publication, was read and confirmed. The following papers were presented: "Some New Physico-Chemical Apparatus," by Dr. C. C. Coffin; "Circulation of Wind in a Cyclonic Area in the Northern Hemisphere," by Capt. W. F. Mitchell.

6th Meeting, Apr. 15, 1931.—Dr. H. L. Bronson was appointed delegate to the Faraday Celebration of the Royal Institution of G. B., London, in Sept. It was resolved that the Institute place on record its deep sense of loss at the death of one of its student members, H. Graeme Fraser. Mr. Fraser, a native of Truro, was an honors student in Chemistry at Dalhousie University and was working on a research shortly to be published in these Transactions when his death, due to an accident in the laboratory, occurred. He was a young man of much promise and had made an excellent beginning in his chosen field of research. He possessed a modest charm of manner which made him well liked by all who knew him. The Institute desires to express sympathy with his family.—The following papers were presented: "Detection and Estimation of Methyl Alcohol in Presence of Ethyl Alcohol," by A. C. Bell and Dr. H. S. King; "Preparation of Hydrazine Sulphate," by H. R. Fraser and Dr. H. S. King; "Influence of Electrolytes on Gelation of Methyl Amine Urate," by Dr. E. G. Young and F. F. Musgrave.

7th Meeting, May 11, 1931.—The following papers were presented: "Studies in Aldehyde-Anhydride-Ester Systems: Introduction," by Miss P. Miller and Dr. C. C. Coffin; "Response of Involuntary Muscle to Pituitrin, Morphine and Quinine," by Dr. N. B. Dreyer.

HARRY PIERS,
Recording Secretary.

ABSTRACTS.

(Papers read before the Institute but not published in the Proceedings).

AN ANALYSIS OF FOX MILK. E. Gordon Young and G. A. Grant Dept. of Biochem., Dalhousie Univ., Halifax, N. S. (Read Nov. 17, 1930). A sample of fox milk is described quantitatively and qualitatively. The ash is very high in its content of calcium and phosphate (86%).

THE RANGE OF THE ALPHA PARTICLES FROM THORIUM. G. H. Henderson and J. L. Nickerson, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read Nov. 17, 1930). The range of the α particles from thorium has been determined by a Wilson chamber method to be $2.59 \pm .05$ cm. at 0°C. and 760 mm. (Published in full in Phys. Rev., Oct. 15, 1930).

SOME EFECTS OF OPIUM ALKALOIDS ON THE INTESTINES OF DIFERENT ANIMALS. N. B. Dreyer, Dept. of Pharmacology, Dalhousie Univ., Halifax, N. S. (Read Dec. 8, 1930). Morphine stimulates the intestine of all the usual laboratory animals. The effect is particularly pronounced in the large intestine. Atropine has an inhibitory action on the morphine stimulation. Codeine, heroine, dionine all have actions similar to that of morphine. Heroine action is as strong as that of morphine, dionine is weaker and codeine has only $\frac{1}{8}$th the activity. Papaverine and narcotine cause relaxation of the gut wall

INTRANUCLEAR DEUTOPLASM IN THE TURBELLARIAN *PRORHYNCHUS APPLANATUS*, RENNELS. E. Ruffin Jones, Dept. of Biology, Dalhousie Univ., Halifax, N. S. (Read Jan. 12, 1931). A new type of deutoplasm, hitherto unreported, is described for Prorhynchus applanatus. Formation takes place within the nucleus through the growth and fusion of nucleoli. The food material contained in the yolk cells is utilized by the developing embryo in the following order,—(1) Cytoplasm of yolk cell, (2) yolk particles in the cytoplasm, (3) intranuclear deutoplasm, (4) nucleoplasm.

HIGH ACIDITY OF QUARRY WATER. S. A. Beatty and A. H. Leim, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Feb. 9, 1931). Water of high acidity (pH3.0) was found issuing from a quarry near Windsor, N. S. Even on considerable dilution it was fatal to hatchery eggs. An explanation of the high acidity is offered based on the occurrence of iron pyrites from which free sulphuric acid is formed.

SOME ACTIONS OF MERCURY SALTS ON THE INTESTINE. N. B. Dreyer, Dept. of Pharmacology, Dalhousie Univ., Halifax, N. S (Read Feb. 9, 1931). Soluble inorganic mercury compounds placed in the gut lumen increase intestinal motility, reflexly, by irritation of the intestinal mucosa. Intravenously, mercury salts dissolved in serum have no action on gut movements. On the isolated perfused intestine, soluble mercury compounds can cause an increase in movements but this is merely part of the toxic action of mercury salts. Dissolved in serum, the toxic action is less marked and motility is not affected to the same extent. The toxicity is also somewhat diminished.

THE POLYSACCHARIDE OF *CHONDRUS CRISPUS*. E. Gordon Young and Margaret R. Butler, Dept of Biochem., Dalhousie Univ., Halifax, N. S. (Read Feb. 9, 1931). The optimal conditions for extraction from the dried plant have been investigated and a method described by which a product free from nitrogen may be obtained. The physical properties of this polysaccharide have been determined. An attempt has been made to ascertain the approximate chemical composition.

SOME NEW PHYSICO-CHEMICAL APPARATUS. C. C. Coffin, Dept. of Chem., Dalhousie Univ., Halifax, N. S. (Read March 9, 1931). A lamp bank rheostat, an internal gas heater and thermoregulator and a "volumestat" have been tried out and found to be satisfactory. The "volumestat" which is based on the electrolytic production of H_2 and O_2 and their recombination on a platinum catalyst has several useful applications which are indicated and discussed.

THE CIRCULATION OF THE WIND IN A CYCLONIC AREA IN THE NORTHERN HEMISPHERE. W. F. Mitchell, Halifax, N. S. (Read March 9, 1931). Actual experiences and observations in the Indian Ocean, Pacific and in the Cabot Straits.

THE PREPARATION OF HYDRAZINE SULPHATE. H. Roy Fraser and Harold S. King, Dept. of Chem., Dalhousie Univ., Halifax, N. S. (Read April 15, 1931). Raschig's method of preparing hydrazine sulphate has been studied in detail and the following major modifications have been devised: (a) By partial hydrolysis of the gelatine by ammonia, prior to the addition of sodium hypochlorite, troublesome foaming has been eliminated; (b) by collecting the ammonia given off during the reaction, the cost of the process is considerably decreased; (c) by making the process semi-continuous, the process has been made practicable on a commercial scale.

THE INFLUENCE OF ELECTROLYTES ON THE GELATION OF METHYL AMINE URATE. E. Gordon Young and Forrest F. Musgrave. Dept. of Biochem., Dalhousie Univ., Halifax, N. S. (Read April 15, 1931). The effect of various electrolytes in promoting gelation of aqueous supersaturated solutions of methyl amine urate has been studied. The cation has been shown to be the active agent. The mineral concentration of the cation which is effective depends upon its valence as in the case of the coagulation of typical suspensoids. Salts of sodium, potassium, ammonium and rubidium have been found to induce gelation. Salts of lithium and caesium were negative in their effect.

NOTICE TO AUTHORS.

To be printed in the volume of the year, a paper must be submitted for publication on or before the date of the May meeting.

Manuscripts should be typewritten (double spaced) on one side of the paper, 8½x11 inches, with 1 to 1½ inch margins. The original typewritten copy should be furnished.

An abstract, not over 200 words in length, must be placed at the beginning of the article. It should be suitable for reproduction in abstract journals. As an index, it should be complete; all the subjects, major and minor, concerning which new information is presented, should be mentioned. As a summary, the abstract should give briefly the conclusions of the article, important advances in experimental technique and in theory, and numerical results of general interest. For an excellent type of abstract see "The Physical Review." A summary at the end of the article should be omitted since it is included in the abstract.

Citations to the literature and notes will be placed at the bottom of the page and should be indicated in the text by superscript numerals, numbered consecutively from 1 up. All footnotes should be collected on a separate manuscript page for the benefit of the printer. The form of citations should be as indicated by the following examples:

[1]Thomson, *Phil. Mag.*, [7] **3**, 241 (1927).

[2]Bachem, *Arch. exptl. Path. Pharm.*, **122**, 69-76(1927); *C. A.*, **22**, 274 (1928). No reference should be cited which has not been consulted by the author himself. When only an abstract is available, it should be indicated in the citation as in the second case above. In abbreviating journal titles employ standard abbreviations used in such well-known abstract journals as "Chemical Abstracts." In citing books, use the form shown in the following example:

[3]Mellor. "*Inorganic and Theoretical Chemistry,*" Longmans, Green and Co., London. **1923**. vol. 4, pp. 625, 645.

In constructing tables arrange them to leave as little waste space as possible. All drawings intended for reproduction should be made about twice the size of the proposed cut on white paper. They should be drawn with extreme care, preferably by a draftsman. Material in each figure should be arranged compactly. It is well where possible to make the longer dimension horizontal. All lines that are to be reproduced must be sufficiently heavy to be clearly legible in the finished cut. When coordinate paper is used, it should be printed in blue only, with the important lines ruled over in black; the black squares in general should be not less than ten millimeters on a side in the printed cut. The lettering of cuts, when reduced, should be about the size of the letters in the text. Where necessary half-tones for reproduction on special paper will be accepted.

Unless page proofs are specifically asked for galley proofs only are sent to the author for correction. Proofs should be corrected with great care and returned by next mail to the Editor, Dr. Harold S. King, Dalhousie University, Halifax, N. S.

The Institute furnishes the author of each paper with 50 reprints without covers gratis. Additional copies may be obtained at reasonable rates if applied for at the time of return of the proof to the Editor. If covers to reprints are desired, an extra charge is made.

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science

HALIFAX, NOVA SCOTIA

VOL XVIII. 1931-1932 PART 2

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1931-32
(Vol. XVIII, Part II)

THE EFFECT OF DESTRUCTION OF THE SPINAL CORD ON OSMOTIC CONTROL IN ELASMOBRANCHS.

A. F. CHAISSON,
St. Francis Xavier University, Antigonish, N. S.

(Received October 16, 1931).

ABSTRACT.

Destruction of the spinal cord in *Raja erinacea* results in the destruction of the mechanism which normally maintains the concentration of the blood above that of sea water.

Unlike the blood concentration of the marine teleosts on which we have data, that of the elasmobranchs, as measured by its freezing point depression (△), is greater than the concentration of the sea water in which the animals are living. Portier and Duval[1] found that the blood of *Scyllium canicula* taken in water of △ 2.08° C. had a △ of 2.17° C. At St. Andrews, N. B. the blood △ of *Raja erinacea* living in sea water of average △ 1.72° C. was 1.80° C. and the greatest variation among the fourteen animals on which the determinations were made was ± .01° C.

The most extensive study of the changes in the blood concentration of elasmobranchs produced by modification of the salinity of the external medium was made by G. G. Scott[2] who used the dogfish *Mustelis canis*. The tail was cut off and the spinal cord destroyed by a wire as far forward as the level of the anterior dorsal fin. The caudal artery was then plugged and the fish transferred to fresh water. It was removed from time to time and a 5 cc. blood sample was taken from the caudal artery. Scott's assumption was that the difference between freezing point depressions of successive blood samples was a measure of the dilution brought about by the unusual medium.

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[1] Portier and Duval, *Compt. rend.*, **174,** 1693-5 (1922).
[2] Scott, *Ann. N. Y. Acad. Sci.*, **23,** 1-75 (1913).

In the course of some experiments carried out during the summer of 1927 at the Atlantic Biological Station, St. Andrews, the writer had occasion to test Scott's technique on the skate, *Raja erinacea*, which is the most common elasmobranch found in the vicinity of the Station. The tail was cut off and a small wooden plug inserted in the caudal artery. The stump of the tail was wrapped in thin sheet rubber. Some of the animals so treated were returned to the tanks in the above condition. Others had the spinal cord destroyed as far forward as the level of the vent and still others had the spinal cord destroyed up to within an inch of the base of the skull.

After twenty-four hours the animals were removed from the tanks and a sample of the tank water was taken at the same time. The heart was exposed ventrally and a canula was tied into the ventral aorta. The heart action served to bleed the animal into a test-tube. The freezing point of the blood sample was determined immediately afterwards by means of the Beckmann apparatus. In every case whole blood was used, the technique being that of Garrey[3]. The freezing points of the samples of tank water taken at the same time the fish were removed were also determined.

Two animals with the tail alone removed and taken from water of △s 1.732 and 1.752 gave blood △s of 1.798 and 1.810 respectively. Two animals with the tail removed and the cord destroyed as far as the vent both showed a blood △ of 1.798 in comparison with tank water △s of 1.768 and 1.756. In the three animals with the greater part of the cord destroyed the blood △s were 1.755, 1.746 and 1.723 in comparison with tank △s of 1.757, 1.746 and 1.722 respectively. These results indicate that destruction of the greater part of the spinal cord of *Raja erinacea* is correlated with the destruction of the mechanism which normally maintains the concentration of the blood above that of the sea water. The result is that the blood concentration drops until it becomes equal to that of the sea water and apparently varies directly with it.

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[3] Garrey, *Biol. Bull.*, 8, 257 (1905).

With respect to the effect of immersion in fresh water on *Musteiis canis*, Scott[2] remarks that after the return of the animal to sea water the blood △ is lowered and the osmotic pressure is increased again but the normal osmotic pressure of the blood is not regained, even though the return to sea water is as long or longer than the time spent in fresh water. This effect cannot, however, be attributed to the fresh water and it is evident from Scott's results that by his technique he has destroyed the mechanism he was attempting to study. Using a different technique the writer[4] has found that *Raja erinacea* may be transferred to fresh water for periods up to forty minutes, after which time the blood concentration was lowered to △ 1.71° C., yet upon return of the animal to sea water, the concentration of the blood returned to its "normal" concentration at △ 1.80° C.

Just how destruction of the spinal cord breaks down the mechanism that normally maintains the concentration of the blood above that of the sea water is a problem regarding which little of a definite nature can be said. In the case of the skate used in these experiments an internal medium, the blood, of △ 1.80° C. and an external medium, sea water, of △ 1.72° C. are separated in the gills by only a layer or two of epithelial cells yet this difference in potential across the membrane is maintained under normal conditions. Apparently the cells next to the water are able to control not only the osmotic pressure but also the proportional salt content of the internal medium[5]. Scott and Denis[6] have shown definitely that in the dogfish the gill membranes constitute the surface where exchange between internal and external media takes place and that the skin does not act as a pathway of absorption. Presumably the gill membranes act similarly in the skate.

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[4] Chaisson, *Contr. Canad. Biol. Fish.*, N. S., **5,** 477-84 (1929).
[5] Huntsman, *Trans. Roy. Soc. Can.*, Sect. V, **20,** 187 (1926).
[6] Scott and Denis, *Am. J. Physiol.*, **32,** 1-7 (1913).

In the destruction of the potential differences across the gill membranes in the animals with the spinal cord destroyed it seems highly probable that shock plays an important part. It is well known that such products of tissue destruction as histamine increase the permeability of capillary walls, and may, in the skate, be responsible for the effect obtained. It is interesting to note in this connection Greene's[7] findings in the case of the chinook salmon, *Oncorhynchus ischawytscha*, taken in fresh water. He reports a direct correlation between low vitality and battered condition of the fish and degree of dilution of the normal blood concentration. In the case of the salmon however, the possibility of surface abrasions complicating the situation must also be kept in mind.

Destruction of the spinal cord is not the only way in which the mechanism which normally maintains the concentration of the blood above that of the sea water may be destroyed. While this mechanism is apparently capable of maintaining much greater differences of potential across the gill membranes than it does normally, it ceases to function if the blood △ is raised beyond 1.71° C. by placing the animals in suitable sea water dilutions[4].

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[7] Greene, *Bull. U. S. Bur. Fish.*, **24,** 429-56 (1905).

THE ALGAL FLORA OF HUDSON BAY. H. P. Bell, Dept. of Biology, Dalhousie Univ., Halifax, N. S. (Read Dec. 14, 1931). During the summers of 1927 to 1930 inclusive, collectors sent to Hudson Bay by the Biological Board of Canada, made sixty-eight collections of marine algae. From these it was possible to make only one hundred and seventy-one identifications, comprising forty species. None of these are peculiar to this region alone, but the distribution and appearance of the plants indicate that the algal association of Hudson Bay is estuarial and Arctic. The fewness of the species compared with the number reported for Hudson Bay, Baffin Bay and other Arctic waters would suggest that thi [illegible]

OBSERVATIONS ON THE ANNUAL GROWTH OF *ASCOPHYLLUM NODOSUM*.

CONSTANCE MACFARLANE,

Dept. of Biology, Dalhousie Univ., Halifax, N. S.

(Received April 20, 1932.)

ABSTRACT.

Growth in length of *Ascophyllum nodosum* (L.) Le Jolis is continuous and the annual increment can be determined by measuring from air bladder to air bladder. At Point Pleasant, Halifax, N. S., the annual linear growth was irregular, ranging from 6 to 15 cm., the average being about 9 cm. The main air bladders appear about May each year. Secondary and smaller ones occur irregularly. The receptacle branches remain attached for about 14 months. They appear first in spring, usually during April or May, and grow in length until the time of ripening. They broaden at the tips during the fall and winter, become noticeably swollen in the spring and summer when they ripen, fall from the plant, and disintegrate. Before the branches ripen and fall, new ones are produced and thus the fruiting of the plant, like the growth of the tip is regular and cyclic.

Ascophyllum nodosum (L.) Le Jolis is a common rockweed in the upper limits of the intertidal zone. In the maritime provinces it is of general occurrence but is more abundant near the mouth of the Bay of Fundy and along the Atlantic coast than in the Gulf of St. Lawrence and Northumberland Strait. The purpose of this article is to give a short account of the changing appearance of the plant throughout the year. The work was done on plants collected at Point Pleasant, Halifax, N. S. During one year collections were made every two weeks, and in addition, regular observations extended over a period of more than four years (1928-32). During this time the findings for Point Pleasant were checked both by collections from many other parts of Halifax Harbour, and by observations at other points in the Maritime Provinces. Particular attention was paid to the rate and extent of growth of the plant as a whole, to the time of occurrence of the air bladders, and especially to the time of ripening of the receptacles.

APICAL GROWTH OF THE PLANT.

The thallus elongates by apical growth, and regularly branches dichotomously once each year. The embryonic tissue producing this growth is never dormant but adds to the length of the plant continuously. Usually in May an air bladder develops by expansion and swelling of the thallus a few millimeters below the apex, in this manner cutting off a new region of the growing tip. This is not a new growing tip, as the growth is an uninterrupted cycle. With the occurrence of the air bladder, however, the plant has grown for a period of approximately a year and arbitrarily the portion of the thallus distal to the new air bladder may be termed the new growing tip. (See fig. for May 13.)

The growing tip is therefore measured from the apical end of the air bladder to the apex and the extent of a year's growth can be estimated by the distance between corresponding regions of two successive air bladders, since these form at about the same time each spring, accompanied by the initiation of the new growing tip. The most rapid growth takes place between early May and late August or early September, while during the late fall and winter the linear growth is not so extensive. Growth is often interrupted artifically, for frequently plants bear evidence, especially in spring and summer, of having been eaten off at the tip by *Littorina littorea*, an injury usually resulting in the compensating growth of one or more side branches occurring a short distance back of the apex. The extent of normal annual linear growth in the specimens collected was somewhat irregular, varying from 4 or 5 cm. in some plants to over 15 cm. in others, the average being about 9 cm. Variations in length appeared not only among different plants but also among branches of the same plant. Moreover growth in the side branches is often not so extensive as that in the main branches and may be as low as 2 cm. for one year as seen by the position of the air bladders in the small side branch in the figure for July 9.

Air Bladders.

Air bladders are usually confined to the vegetative branches, although occasionally they appear near the base of the receptacle branches. Their occurrence on these branches, however, is comparatively rare and is usually accompanied by other irregularities such as the bifurcation of the branch near the tip. (See fig. for March 12.) The main bladders as already noted, develop in May on the main branches, and are usually followed closely by dichotomy of the branch. Secondary air bladders may also occur but these can usually be distinguished by their size or position and therefore do not interfere with the determination of the annual growth. (See fig. for Aug. 15 where two air bladders are seen between two dichotomous branchings, and also the fig. for Sept. 14 where two bladders occur very close together, the secondary and younger one being much the smaller.)

RECEPTACLES.

The gametes are born in terminal receptacles on specialized, distinct, simple, lateral branches, limited to a little more than the distal half of the frond. These lateral receptacle branches, according to Oltmanns[1], develop from embryonic cells in slit-like crypts on the sides of the thallus. They occur also at the top or sides of the air bladders and usually make their appearance in April or May, although in some plants they have been observed as early as January.

During the first few months the chief growth is linear. There is no indication of receptacles until late summer and autumn when in addition to growth of the branches in length there is a noticeable enlargement at the tips. This enlargement continues throughout the winter and the receptacle branches attain their maximum size about April. As a rule the developing conceptacles are evident shortly after the differentiation of the swollen receptacles. From this time on the conceptacles become more clearly defined, until by April a few gametes may be discharged. During the months of May and June the plants attract attention by their heavy burden of large ripe receptacles. These discharge gametes until about the end of the month when they all fall off leaving the plants suddenly bare. Occasional exceptions are found, some plants losing their receptacles at an earlier date and some retaining healthy fruiting branches until late September. In spite of these rare exceptions, the sudden shedding of the fruiting branches is an outstanding feature of *Ascophyllum.*

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[1] Oltmanns, *Morphologie u.Biologie d. Algen.*, 2nd edit. II Bd. Jena, 1922. p. 195.

Since the new branches as previously stated arise in spring, and the old ones do not drop off until the end of June, there are attached to the plant during the season of ripening and fruiting two sets of receptacle branches. The reproductive cycle of one year overlaps that of the next and in this way it is different from the unbroken cycle of linear growth in the main vegetative axis and its branches.

IRREGULARITIES IN THE LATERAL BRANCHES.

Not all lateral branches become fertile. Some remain vegetative exhibiting the lack of differentiation which is a prominent feature common to all algae. A great deal of embryonic tissue is present at all times and in the event of injury to or loss of branches or growing tips, it develops adventitious branches. These grow out from embryonic cells situated in the slit-like crypts near the base of the old branch or near the site of the injury if it be to the main thallus. (See fig. for Oct. 12.) Another irregularity is that two bifurcations may occur in a branch in one year. Sometimes the second bifurcation follows so closely upon the first that three branches appear to arise from the one spot. This irregular branching is more common after any form of injury but may occur where no injury is apparent. (See branch on right of fig. for Sept. 26 or branches on left of fig. for Nov. 15.) The fate of the young lateral branches cannot be determined with certainty until after several months' growth. If the branch shows a dichotomy in its early stages, it is likely to remain vegetative. The fruiting branches usually show no such branching, and dichotomy when it does occur here is usually late and confined to the swollen tips. The irregularities of diochotomy, development of air bladders, and other variations in the side branches have no effect on the development of receptacles or main air bladders.

COMPARISON WITH OTHER REGIONS.

The yearly growth of *Ascophyllum nodosum* at Halifax as given in this account corresponds closely with that of plants elsewhere in the maritime provinces. The size and quantity vary in different places. In general, plants found in the Bay of Fundy are much larger and more plentiful than those at Halifax, while in the Northumberland Strait and Gulf of St. Lawrence they are smaller and less abundant. But these differences do not affect the life cycle, and from observations that it was possible to make, it was found that the air bladders appear and the receptacles develop, fruit, and drop off at about the same time throughout the whole region.

EXPLANATION OF PLATES.

June 23. New growing tip well developed. Air bladders large. Old receptacles large and ripe. New receptacle branches developing in length.

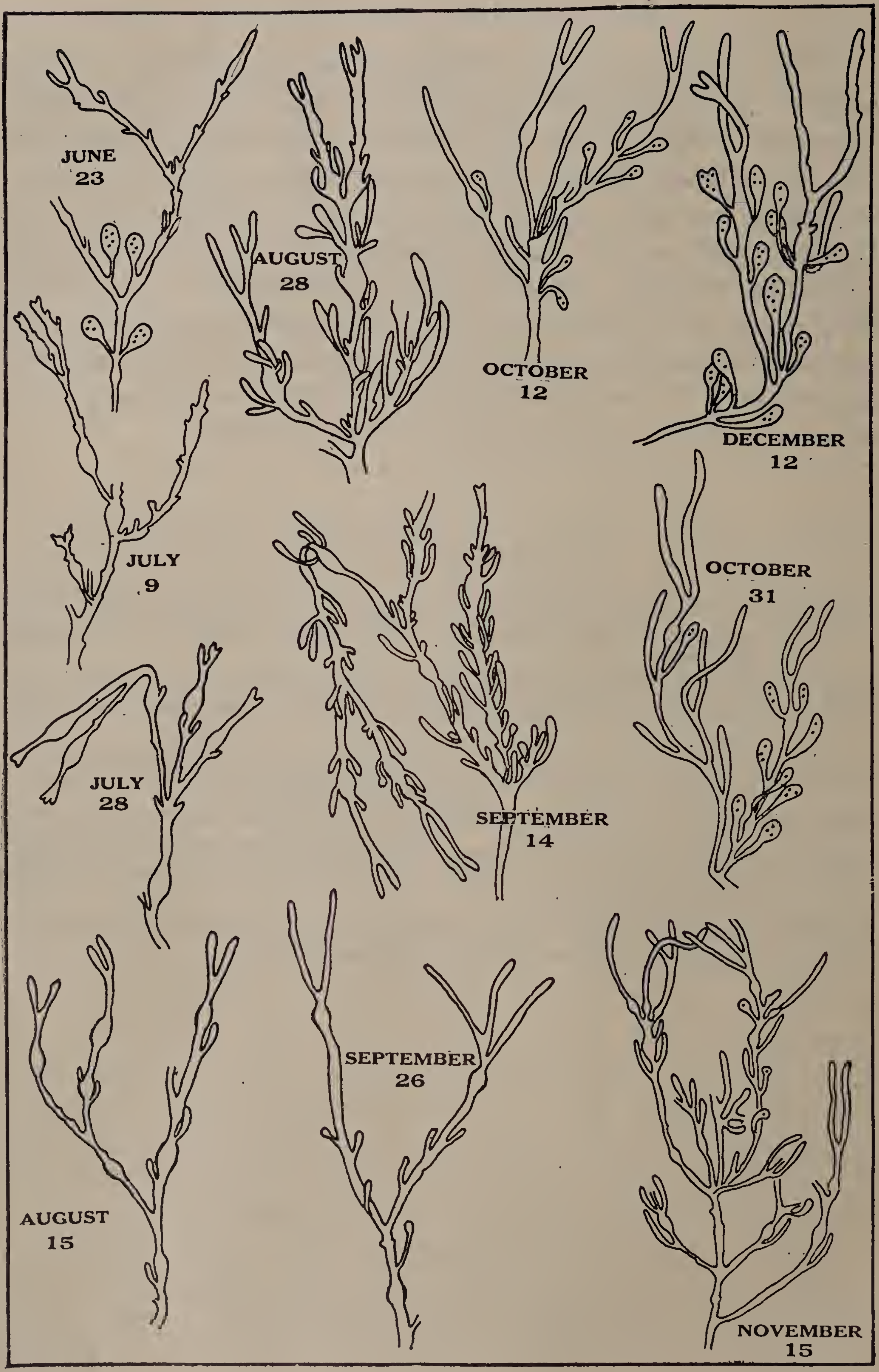
July 9—Sept. 26. Growing tip elongating and bifurcating. Old receptacles fallen. New receptacle branches showing further development.

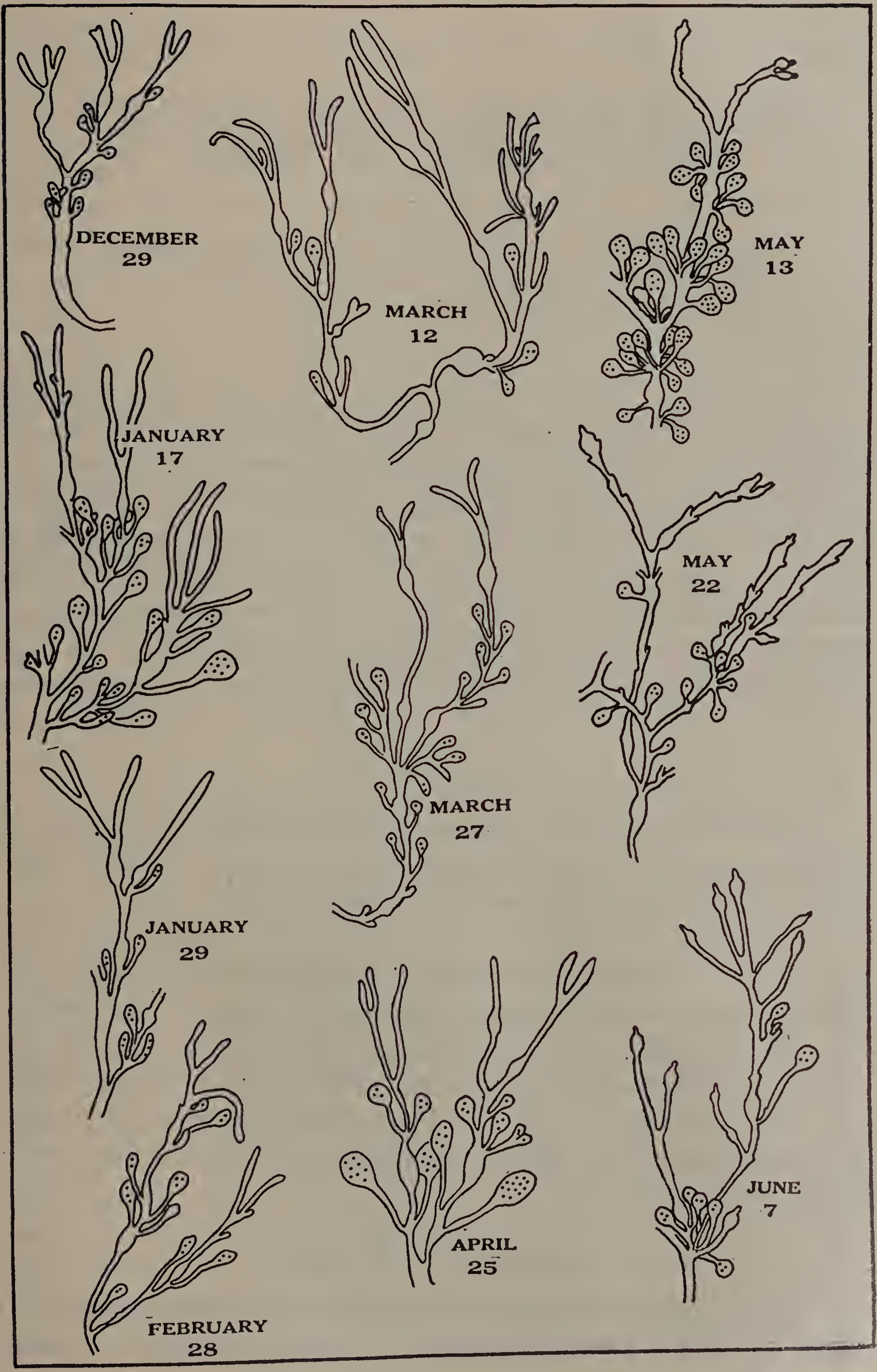
Oct. 12—Nov. 15. Receptacle branches growing in length and broadening and swelling at tips. Conceptacles appearing.

Dec. 12—March 27. Further development of receptacles and conceptacles.

April 25—May 13. Growing tip reaching full length, air bladders formed and new growing tip initiated. Receptacles ripe. New receptacle branches appearing.

May 22—June 7. Further development of growing tip and of new receptacle branches. Old receptacles ripening and ripe.


JUNE 23
AUGUST 28
OCTOBER 12
DECEMBER 12
JULY 9
OCTOBER 31
JULY 28
SEPTEMBER 14
AUGUST 15
SEPTEMBER 26
NOVEMBER 15


DECEMBER 29
MARCH 12
MAY 13
JANUARY 17
MAY 22
MARCH 27
JANUARY 29
JUNE 7
APRIL 25
FEBRUARY 28

PHYSICAL CHANGES DURING THE EARLY DEVELOPMENT OF THE SALMON.

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ABSTRACT.

The component parts of salmon eggs were weighed periodically to determine the rates of growth and expenditure of energy during, or at, different stages. There is no measurable gain or loss in the wet and dry weight of the egg, from nine days after fertilization until the beginning of hatching. An increase in the wet weight of the larva (embryo plus yolk) begins shortly before hatching and continues until the yolk sac is almost absorbed. There is a rapid loss in dry weight owing to protein combustion, which begins four days before hatching. Larvae hatched artificially two weeks before the normal hatching period, use a considerable quantity of material for combustion, which would otherwise have been turned into embryonic tissue. The osmotic pressure of the egg contents as indicated by the freezing point depression, rises before hatching. A simultaneous decrease in the quantity of perivitelline fluid may offer an explanation.

INTRODUCTION.

The work reported in this paper was carried out with a view to answering the following questions about the development of the Atlantic salmon, *Salmo salar* Linn:

(a) What are the changes in weight which occur in various parts of the salmon eggs and larvae, and how may these be interpreted in terms of the developmental mechanics? (b) Is there any change in the osmotic pressure of the egg contents prior to hatching? (c) What is the approximate rate of expenditure of energy in the hatched larvae? (d) What are the effects of artificial hatching of larvae some weeks before the normal time?

MATERIAL AND METHODS.

The material used was obtained from the Federal Government Fish Hatchery, Bedford, N. S. and reared in a small hatchery in the zoological laboratory, Dalhousie University. Batches of eggs were obtained from the government hatchery at various times during the winter. The water temperature at the hatchery averaged less than 5°C while that in the laboratory was somewhat more variable, and averaged 10.2°C. The rate of growth in the Bedford hatchery was accordingly much slower than in the laboratory. It was therefore impracticable to use the number of days after fertilization as an index of the developmental stage of the embryos, since some had been reared in the hatchery longer than others. For instance "thirty-five days after fertilization", might indicate different stages in development when applied to different batches. For this reason the date of hatching is taken as zero time instead of the date of fertilization, and the developmental stage of the embryo is given as the number of days before or after this time. A slight difficulty with this method was in reckoning zero time, since hatching normally occupies several days. Inaccuracies developed with reference to observations made close to hatching time, but these were relatively unimportant.

The following experimental data were recorded: (a) a history of the eggs and larvae, which included a daily temperature record, length measurements, the approximate death rate, and a record of gross morphological changes during development; (b) the estimation of wet and dry weights of the entire egg, shell, larva, embryo and yolk; (c) the estimation of he freezing point depression of the egg contents.

By "wet weight" is meant the weight of the material with surface moisture removed between sheets of filter paper; the "dry weight" was obtained by drying the material to a constant weight at 102°C.

For a wet weight estimation ten eggs were removed from the hatching tray, and cleaned with filter paper in distilled water, to remove silt and fungus adhering to the shell. The eggs were then rolled between sheets of filter paper, to remove the surface moisture, and were weighed in a tared glass container. They were then cut open to ensure thorough drying, and placed in the oven. Weighings were made at one hour intervals until a constant weight was reached.

According to Becher[1] the shell ("zona radiata"), of salmnoid eggs is perforated by numerous radial canals of about 1μ diameter. These are so close together as to give the magnified membrane a sieve-like appearance. It was found that if a previously dried egg were squeezed, moisture would appear on its surface. Therefore in removing surface moisture by filter paper as described above, a small amount of perivitelline fluid may have been lost, but since the drying technique was carefully standardized it is not believed that the results could have been measurably affected.

Attempts were made to obtain the wet weight of larvae, and of yolks and embryos separately. The same procedure was followed as with the eggs, but the practical difficulty of removing surface moisture from such soft material, was so great that the results obtained from this phase of the work are not reported.

A procedure believed to be new, for estimating the wet weight of this material was however worked out. It consisted first, in determining the specific gravity of the material, (yolk or embryo) and then weighing it in a wide mouthed specific gravity bottle containing distilled water at a known temperature. Then, after making a correction for the expansion of water due to temperature variation, the wet weight of the material could be estimated by the following equation:

$$\begin{array}{c}\text{Wet wt. of}\\ \text{material}\end{array} = \frac{\text{Sp. Gr. of mat. (wt. of mat.} + \text{water} - \text{vol. of mat.} + \text{water)}}{\text{Sp. Gr. of material} - 1}$$

The specific gravity of the material was obtained by placing samples in solutions of NaCl of varying concentration, until it was found in what strength of solution the material neither floated nor sunk. The specific gravity of this NaCl could then be measured, and was of course, equal to that of the larva.

In making weight estimations of embryos or yolks separately two methods were employed; the first was by obtaining the weight of ten larvae (embryo plus yolk sac), and the weight of twenty embryos removed from the yolk with fine scissors in 0.7% NaCl. The average weight of embryo was then subtracted from that of embryo plus yolk, giving average weight of the yolk. The second method which was more commonly used, consisted in carefully tearing the ectoderm and somatic mesoderm with fine forceps at the point where the posterior part of the yolk sac was joined to the body of the embryo. The larva in earlier stages possesses a rather large coelmic space in this region which makes the operation comparatively easy. The yolk sac, held together by the two layers, splanchnic mesoderm and endoderm, could then be shaken free from the embryo, and the weights of both could be determined directly.

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[1] Becher, *Z. Zellforsch. mikroskop. Anat.*, **13$\frac{3}{4}$**, 591 (1928).

For making estimations of the weight of the shell the eggs were hatched by means of fine forceps, having first been thoroughly cleaned to remove fungus and silt. The empty shells were freed from adherent water by pressing between several sheets of filter paper, placed in a glass container and weighed; this gave the wet weight. They were then dried at 102°C to a constant weight (the dry weight).

Estimations of the freezing point depression of egg contents and larvae were obtained by a Micro-Beckman apparatus. The material was first thoroughly crushed in a dish surrounded by a freezing mixture of salt and ice to prevent evaporation, and was then filtered into the Beckman tube.

EGG HISTORY.

Table 1 gives the gross morphological changes in the egg and larvae during development. The chief thing of interest here is the sudden rise in embryonic activity which takes place on the thirty-third day before hatching and continues for nine days. During this period the slight jar which occurred in moving eggs from the hatching tray, caused the yolks to coagulate in less than ten minutes. This period of activity and susceptibility to mechanical shock passed, and the eggs became comparatively hardy, until the time of hatch-

TABLE 1.

Egg History.

days before and after hatching	average length in mm.	Remarks	
—41		Eggs fertilized	
—37		Blastodisc formed	
—36		64—cell stage (approximately)	
		Daily mortality about 50.	
—33		Blastula or gastrula	
—30	1.5 mm	Prim. streak and medullary tube forming.	Period of highest growth rate, greatest daily mortality, and greatest susceptibility to mechanical shock.
—29	1.9 "	Daily mortality about 250	
—28	3.0 "		
—27	4.0 "	Neural cord and optic vesicles forming.	
—24	5.0 "	"Early eyed stage" eyes slightly pigmented; vitelline and body circulation sluggish; muscular movements, feeble.	
—23		Period of high activity passed; daily death rate 10-20.	
—20	6.0 "	Vitelline and body circulation well developed; embryos showing active movements; eyes pigmented ("eyed" stage).	
—19	7.5 "		
—8	12.0 "		
—7		A few precocious eggs hatching.	
		Death rate rose to 50-100	
—3	16.4 "	Eggs hatching in large numbers	
—1	15.80 "		
0	15.75 "	Hatching progressing rapidly	
4	17.50 "	Hatching completed	
9	18.60 "		
10	19.60 "		
21	20.9 "		
25	22.3 "		
31	22.5 "	Irregularities in length measurement doubtless due to inclusion of precocious individuals, not uncommon in the "hatch."	
35	22.9 "		
44	24.5 "		
51	23.25 "		
62	25.75 "		
68	25.5 "	Yolk sac practically absorbed; body heavily pigmented; parr marks showing; fry active and apparently not suffering from hunger.	
74	26.6 "		
78	25.7 "		

ing when the death rate again rose. The first period of high death rate coincides with the time of organogenesis in the embryo, while the later one occurs at the time when the injurious effect of the hatching enzyme is greatest, and is no doubt largely caused by this[2].

The Shell.

Table 3 gives the wet weight, dry weight and percentage water, of groups of thirty shells determined over a period of from twenty-eight to zero days before hatching. Figures II and III represent this graphically. It will be noted that there is an increase in wet weight and percentage water, accompanied by a decrease in solid content. The decrease in solid content may be due to either or both of the following causes: (a) a decrease in lipoid material in the capsule—this was determined by Scheminzky and Gauster[3], by staining with osmic acid—or (b) to the hydrolysing action of the enzyme which brings about hatching, and which may be present in small quantities for a considerable time before this period[4].

The increase in water may also be due to two causes: it may be brought about by the action of the enzyme mentioned above, or by the action of the fungus *Saprolegnia* sp., or it may be due to imbibition of water by the proteins which form the bulk of the shell. In other words an increase in hydrogen ion concentration in the tissue may cause the protein molecules to take up water as is the case with gelatine and some biological membranes. Changes in the hydrogen ion concentration of shell membranes however, have not yet been investigated experimentally.

The Egg as a Whole.

Table 2 and Figure IV give the results of weight estmations of the total egg. The methods employed show no fluctuations in wet or dry weight, or water content. There is actually a slight increase in wet weight since the shell has been shown to absorb water; but at the time of hatching when the shell is at its heaviest, it only comprised 0.3% of the total weight of the egg and therefore may be assumed to have had no effect on the figures under consideration.

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[2] Bourdin, *Compt. rend. soc. biol.*, **95**, 33 (1926); Kronfeld and Scheminzky, *Arch. Entwicklungsmech. Organ.*, **107**, 129 (1926).

[3] Scheminzky and Gauster, *Arch. Entwicklungsmech. Organ.*, **101**, (1924).

[4] Wintrebert, *Compt. rend. soc. biol.*, **72**, 729 (1912).

There was, then, no measurable increase in wet weight. This agreed with the findings of Kronfeld and Scheminzky[2] who stated that although the egg took up water for a short time after fertilization, the water content thereafter remained the same until the period of hatching, without further absorption from the exterior. The yolk therefore has until hatching, a limited water supply which is constantly being drawn upon by the growing embryo. As water is taken from the yolk by the embryo, there should be a progressive concentration of yolk material and consequent rise in osmotic pressure. It is to this rise in osmotic pressure in the yolk that Kronfeld and Scheminzky attribute the slackening in rate of embryonic development, which they noted towards the end of the egg phase of development.

The results of freezing point depression determinations, showed a lowering of the freezing point as the egg approached hatching. This may be explained by the concentration of yolk material and decrease in perivitelline fluid. This point is further discussed in a subsequent section.

The conclusions are (1) that the egg does not take up water from the outside and (2) that the perivitelline fluid diminishes in quantity.

THE LARVA.

The Figures for wet and dry weights and water content are given in Table 2 and Figures V and VI. The date concerning variations in wet weight and water content are too scanty to form the basis for any conclusions except that water is taken up by the larvae after hatching. If the curve in Figure

TABLE 2.

e. . . . . .eggs (in groups of ten).
l. . . . . .larvae (in groups of ten).
x. . . . . .normal.
o. . . . . .artificially hatched.

days before and after hatching	material	wet weight in grams	dry weight in grams	water in grams	% water	% dry material
—32	e	1.569	0.483	1.085	69.3	30.6
—30	e	1.557	0.516	1.041	66.8	33.1
—19	e	1.612	0.503	1.109	68.8	31.1
—19	e	1.702	0.534	1.68	68.6	31.3
—19	e	1.428	0.448	0.979	68.5	31.4
—19	l x	1.227	0.470	0.757	60.9	39.0
—17	e	1.503	0.489	1.044	68.1	31.8
—17	e	1.569	0.481	1.088	69.3	30.6
—17	l x	1.307	0.496	0.811	62.1	37.8
—14	e	1.533	0.489	1.044	69.1	31.8
—12	e	1.599	0.489	1.109	69.3	30.6
—12	e	1.439	0.459	0.979	68.0	31.9
—12	1 x	1.272	0.456	0.816	64.1	35.8
—10	e	1.485	0.473	1.011	68.1	31.8
—9	e	1.536	0.469	1.065	69.4	30.5
—9	e	1.537	0.515	1.022	66.4	33.5
—9	l x	1.313	0.484	0.829	63.1	36.8
—8	l x	1.322	0.493	0.828	62.6	37.3
—6	e	1.400	0.431	0.969	69.2	30.7
—2	l x	1.303	0.464	0.839	64.4	35.5
—2	l o		0.457			

0	e	1.409	0.442	0.967	68.6	31.3
0	e	1.588	0.498	1.090	68.6	31.3
0	e	1.684	0.507	1.177	69.8	30.1
2	1 x	1.319	0.473	0.846	64.1	35.8
2	1 o		0.453			
2	1 x		0.388			
8	1 o		0.312			
8	1 x		0.441			
13	1 x		0.404			
20	1 x	1.363	0.445	0.918	67.3	32.6
34	1 x		0.387			
40	1 x		0.381			
52	1 x	1.494				
64	1 x		0.226			
80	1 x	1.326	0.324	1.002	75.4	24.5

VI may be accepted as giving an approximate picture of events then the larvae begin to take up water some time before hatching. This is to be expected since the shell membrane becomes soft just before the time of hatching and probably permits some water to enter the egg[5].

The larval dry weight begins to fall about four days before hatching. The loss in dry weight may only be explained by the burning of material. The fact that the loss shows shortly before hatching is probably due to two causes, the initiation of, or at least, the increased activity of the hatching enzyme; and the greatly increased muscular activity of the embryo, which accompanies the hatching phenomenon.

After hatching, the embryo becomes a free swimming, gill-breathing organism with the result that a large quantity of food is turned into energy rather than into embryo.

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[5] Hayes, *Biochem, J.*, **24**, 723 (1930).

It was found (Table 2) that in a thirty-eight day period, beginning two days after hatching, a group of ten larvae lost 0.092 grams of dry material. Hayes[6] found that until 110 days after hatching the protein content fell while the fat content rose. It has been assumed therefore that this loss in dry weight represents protein which has been burned (the quantity of carbohydrate present in the yolk is negligible). Lusk[7] found that one gram of animal protein in burning uses 964.0 c.c. of oxygen. The weight of one embryo during the period in question was approximately 0.040 grams (the yolk itself is inert and need not be considered). Sufficient data are now at hand to calculate roughly the oxygen requirements of one gram of embryonic tissue per minute.

$$\frac{964.0\times 0.092}{0.040\times 54720}=0.03 \text{ c.c. } O_2 \text{ required by 1 gm. embryonic tissue per minute.}$$

Bayliss[8] gives figures for the oxygen requirements of different tissues in the cat: the submaxillary gland in the resting stage consumes 0.027 c.c. of oxygen per gram per minute; the liver consumes 0.024 c.c. per gram per minute. These figures are for actively metabolising tissues in homiothermic animals, and the fact that they are of the same order as those of the embryonic tissue, would indicate a very high metabolic rate in the latter.

EMBRYO AND YOLK.

The results of the estimations for separate embryos and yolks are given in Table 3 and Figures VII and VIII.

The curve for the dry weight of yolks does not inflect until the thirteenth day after hatching, while the curve for the dry weight of larvae drops at about the fourth day before hatching. The error is probably in the yolk determination since these are not so numerous as those for the larvae.

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[6] Ibid. p. 735.

[7] Lusk, Graham, *Science of Nutrition*, W. B. Saunders Co., Philadelphia & London, 3rd. edition **1923,** p. 28.

[8] Bayliss, "*Principles of General Physiology,*" Longmans, Green and Co., London, **1920,** pp. 342-3.

TABLE 3.

em = embryos (in groups of twenty).
y = yolks (in groups of ten).
s = shells (in groups of thirty).
x = normal.
o = artifically hatched.

days before and after hatching	material	wet weight in grams	dry weight in grams	water in grams	% water	% dry material
—28	s	0.150	0.039	0.111	74.0	25.9
—25	s	0.177	0.044	0.133	75.2	24.7
—19	s	0.165	0.033	0.132	80.0	19.9
—12	s	0.147	0.025	0.122	82.9	17.0
—10	s	0.158	0.025	0.133	84.2	15.7
—10	em x	0.306	0.014	0.291	95.0	4.4
—9	s	0.161	0.027	0.134	83.2	16.7
—8	em x		0.012			
—8	em o		0.011			
—6	s	0.156	0.023	0.133	85.2	14.7
—3	s	0.183	0.021	0.161	88.2	12.7
—2	em x		0.080			
—2	y o		0.415			
—1	s	0.152	0.032	0.119	84.2	15.7
—1	y x		0.375			
0	s	0.175	0.046	0.128	73.4	26.5
0	s	0.172	0.018	0.154	89.5	10.4
0	em o		0.014			
0	y o		0.398			
2	y x		0.373			
7	em o		0.040			
7	y o		0.396			

8	em x		0.042			
8	y x		0.372			
13	em x		0.054			
13	y x		0.377			
13	y o		0.287			
14	em o		0.016			
26	em x	1.093	0.095	0.998	91.3	8.6
34	em x		0.120			
40	em x		0.120			

Figure VII shows that the dry weight of yolks of artificially hatched larvae is considerably greater than that of the normal. This is explained by the fact that the two groups of larvae were taken from different batches of eggs. They are placed together in this figure because there appears to be so much difference in the rate of expenditure of material.

Figure VIII is of interest, as it shows a difference between the rates at which embryo-building is going on in the two groups of larvae, those hatched artificially some time before the regular time of hatching and those allowed to hatch normally.

In the normal larvae 10 days before hatching, there appears to be little growth. Then the embryo begins to gain rapidly in dry weight. The dry weight of the larva as a whole begins to decrease about four days after hatching so we may conclude that the process of embryo-building in normal larvae is interrupted just before the hatching period, but is resumed shortly after. The curve for increase in dry weight of artifically hatched individuals shows a slow but uniform increase without the sharp rise after the normal hatching period and thus gives support to the view that hatching interferes with development.

A comparison of Figures VII and VIII make it appear that the artificially hatched larvae are burning a great deal more material for maintenance and energy, than the normal animals.

The conclusion that may be drawn from this, is that in prematurely introducing the larvae to active life we bring about an expenditure of food material which cannot be justified by the fact that the animal has been spared the effort of hatching.

The two figures for percentage water of the embryos alone, show that there is a fall from 95% to 91.3% over a period of 36 days. This is further borne out by the fact that the specific gravity of embryos also becomes higher, as larval development proceeds, rising from 1.036 to 1.061 in approximately the same length of time. This is doubtless due to the formation of denser tissue such as cartilage and bone.

FREEZING POINT DEPRESSION OF EGG CONTENTS.

The figures for freezing point depression determinations are given in Table 4.

TABLE 4.

Freezing point depression of egg contents and weight of perivitelline fluid.

days before hatching	egg contents Δ F. Pt.	periv. fluid in gms.
23	0. 459°C	
19		0. 189
12	0. 515°C	0. 100
12	0. 560°C	
9		0. 062
0	0. 640°C	
0	0. 662°C	

Svetlov[9] working with the eggs of *Salmo fario* found that the freezing point depression of the yolk and perivitelline fluid remained constant throughout the egg phase of development, while the freezing point of the total egg contents rose slightly, that is, he found that there was a greater dilution of egg contents as the egg approached hatching. This he explained by the increase in volume of perivitelline fluid.

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[9] Svetlov, *Arch. Entwicklungsmech. Organ.*, **114**, 771 (1929).

The results given in Table 3, which are directly opposite to Svetlov's, show that there is a drop in the freezing point of the egg contents as the hatching period is approached. The figures shown for weight of perivitelline fluid were obtained by subtracting the combined weights of shell and larva from the weight of the egg. These figures show a loss rather than a gain of perivitelline fluid. The fact that the eggs used in the present work were those of *Salmo salar* while Svetlov used the eggs of *Salmo fario*, does not appear to be a satisfactory explanation for the difference in results.

Svetlov suggests that the egg shell functions merely as a mechanical protection for the contents; that it serves as a shock-absorber, and as a filter which prevents the entry of bacteria, and the loss of protein. The results of his measurements of freezing point depression bear this out, since with the absorption of yolk material by the embryo, the larva would decrease in volume, and water might be expected to enter the egg from the outside. If on the other hand, the results of the present work are to be accepted, the only possible explanation would be that the perivitelline fluid is extruded, or absorbed by the shell. Of these two explanations, the latter is the more probable one, although it is by no means satisfactory since the amount of water absorbed by the shell is considerably less then the calculated loss of perivitelline fluid. No other explanation is offered, but it is evident that further investigation on this point is desirable.

The writer wishes to express his thanks for the advice, criticism and practical assistance of Dr. F. R. Hayes under whose direction this work was carried out.

The living material used was provided through the courtesy of Mr. George Heatley, Superintendent of the Federal Government Fish Hatchery, Bedford, N. S.

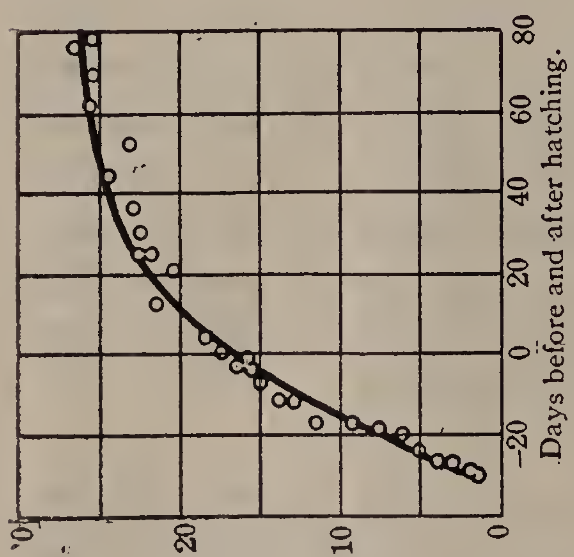

Fig. I. Linear Growth Rate of Embryo.

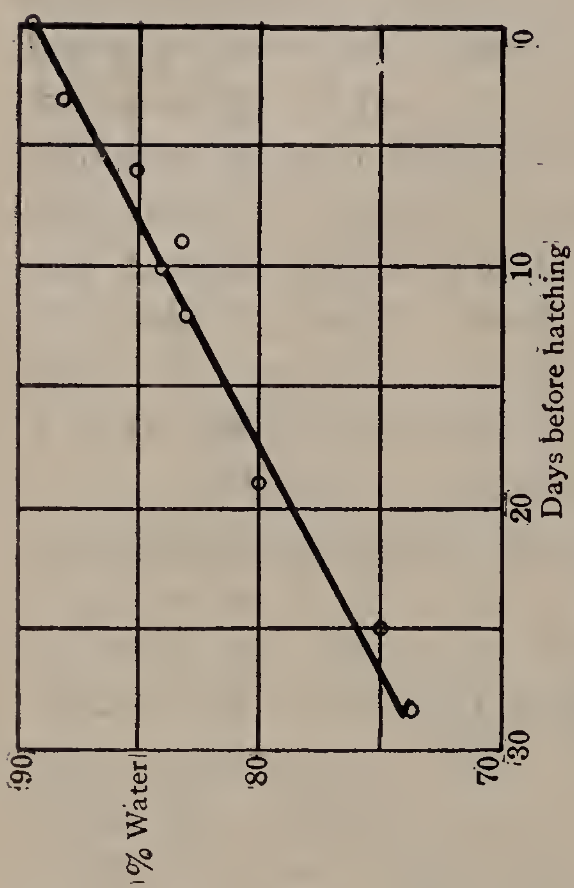

Fig. II. Shell: % Water.

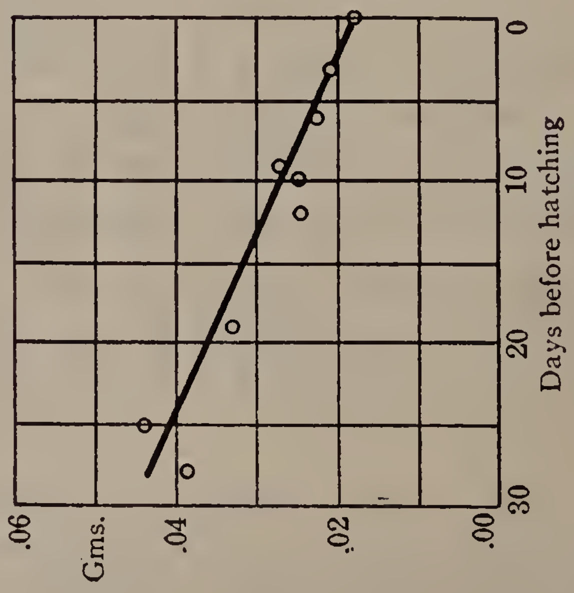

Fig. III. Shell: Dry Weight.

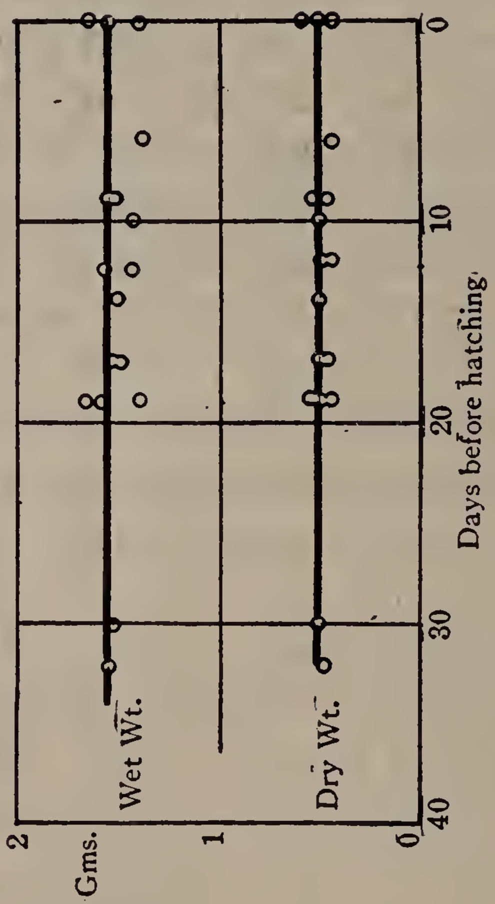

Fig. IV. Egg: Wet and Dry Weight.

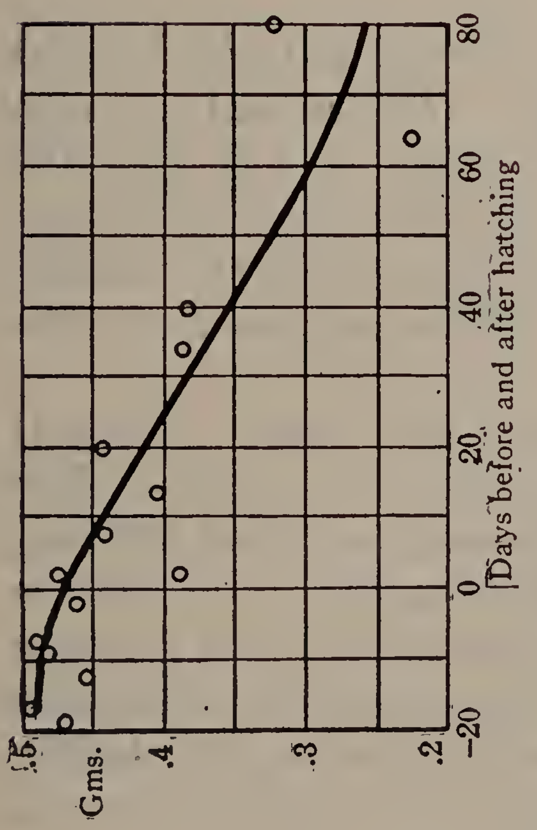

Fig. V. Larva: Dry Weight.

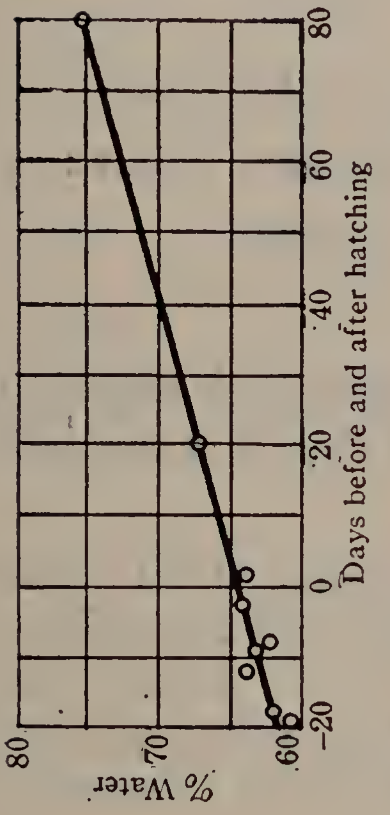

Fig. VI. Larva: % Water.

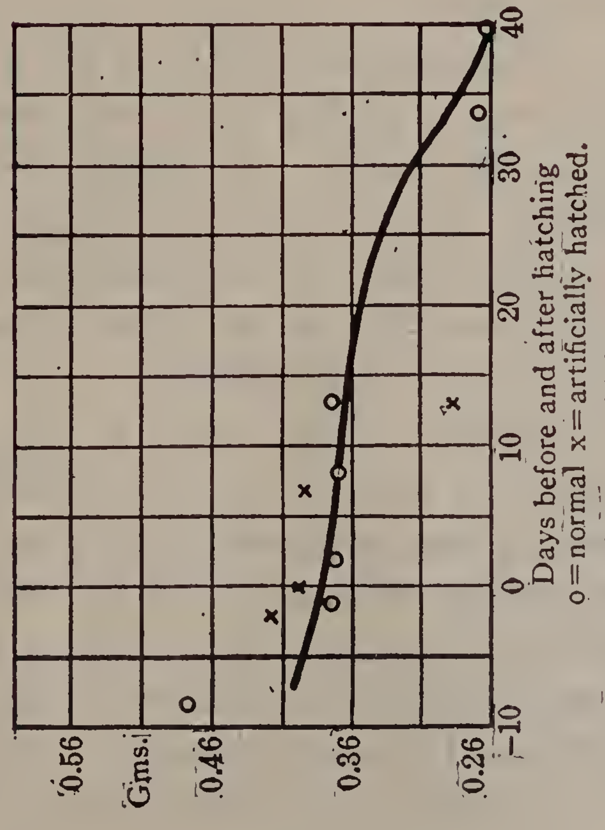

Fig. VII. Yolk: Dry Weight.

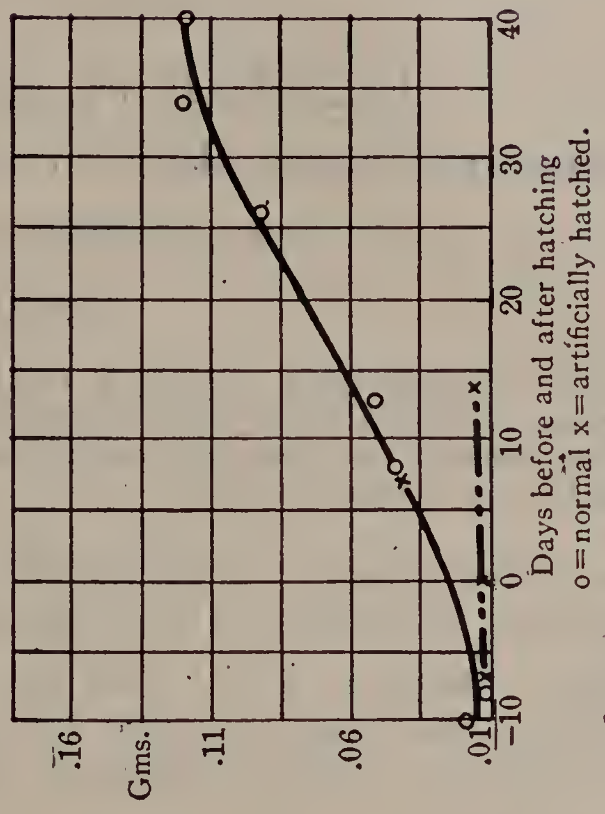

Fig. VIII. Embryo: Dry Weight.

RESPONSES OF THE BLADDER AND SEMINAL VESICLE IN THE RAT.

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(Received November 11, 1932).

ABSTRACT.

The sympathetic is motor to the bladder and seminal vesicle of the rat. It contains very few, if any, inhibitory fibres. The musculature of the bladder and seminal vesicle does not seem to be controlled in any way by the parasympathetic.

Stimulation of the sympathetic (hypogastric) causes in the cat brief excitation of the bladder followed by inhibition[1, 2, 3]. Other animals give varying results[1]. In all cases the sympathetic response can be duplicated by adrenaline [1, 4]. The seminal vesicle of the rabbit and cat is stimulated by adrenaline[5].

Preparation of Rat. The rat is anaesthetized with luminal (150 mg. per Kg. of body weight). The luminal is given intraperitoneally. A small metal cannula is put into the external jugular vein; through this all injections are made. A tracheotomy is then performed. Following this the bladder is exposed by a mid-line incision. The operation for the seminal vesicle is similar.

Bladder. The ureters are ligated low down. A metal cannula is passed into the bladder through the urethra. The cannula has terminal and lateral openings to avoid blocking by contact with the bladder wall. It is secured by a ligature around the neck of the bladder and is connected to a sensitive Marey tambour by rubber tubing. The pressure in the bladder is about 15 cm. of water. The movements of the bladder as a whole are recorded by this method; no attempt was made to determine the action of drugs on the trigonal region.

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[1] Elliot, *J. Physiol.*, **35,** 367 (1906-1907).
[2] Stewart, *Am. J. Physiol.*, **2,** 182 (1898).
[3] Edmunds and Roth, *J. Pharmacol.*, **15,** 189 (1920).
[4] Lewandowsky, *Centr. Physiol.*, **14,** 433 (1890).
[5] Langley, *J. Physiol.*. **27,** 237 (1901-02).

Seminal Vesicle. We found the following preparation to give the best results. The bladder and urethra are tied off to avoid interference. The vas is tied off above the seminal vesicle. The vesicle is held up and a glass cannula is inserted into its tip. The seminal fluid is washed out with warm saline. The cannula is connected to a tambour in the same way as the bladder. The pressure is about the same as in the case of the bladder.

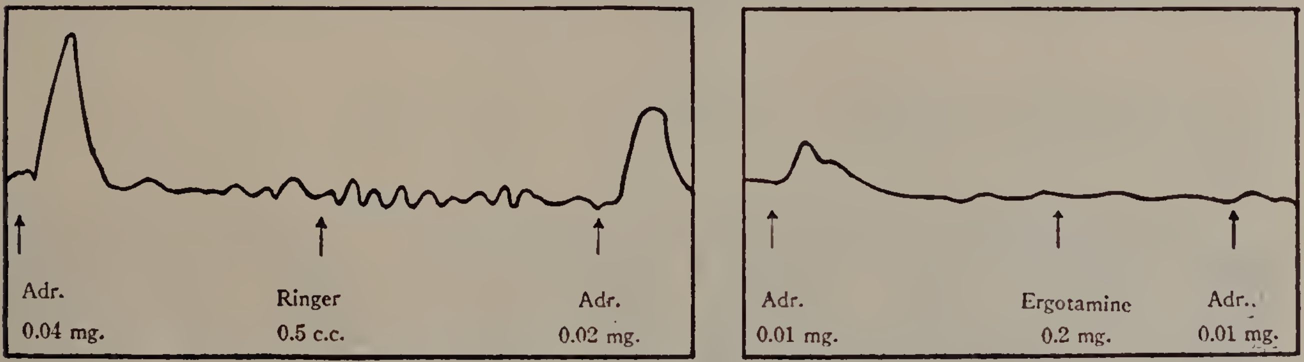

Fig. I and II. Rat. Bladder.

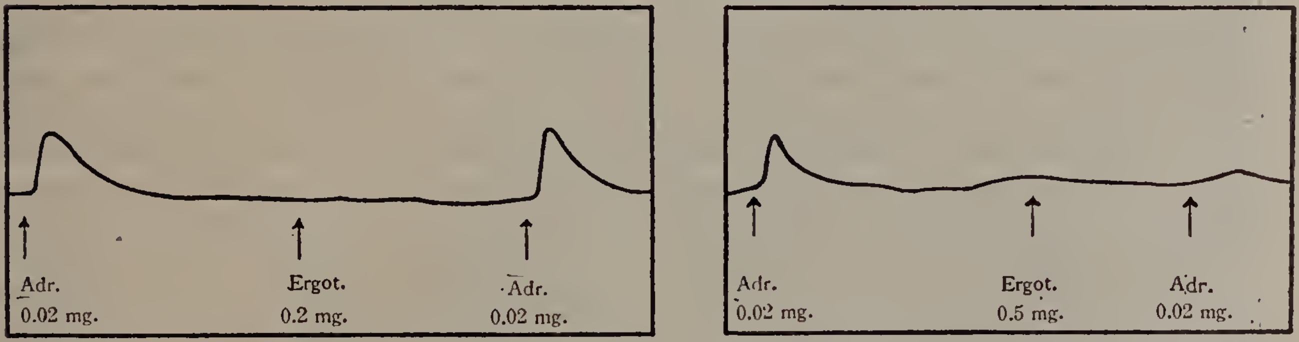

Fig. III and IV. Rat. Seminal Vesicle.

RESULTS.

The results are illustrated in the figures.

Bladder. Adrenaline (0.02—0.04 mg. in 0.5 c.c.) caused a strong single contraction (Fig. I). Repeated doses did not change the response. Large doses of ergotamine (0.2—0.5 mg.) abolish the action of adrenaline. The ergotamine itself had no action; there was no inhibition following the ergotamine on injection of adrenaline. (Fig. II).

The parasympathetic drugs (pilocarpine 0.1 mg., atropine 0.1 mg.) had no effect.

Pituitrin (0.25 unit) caused momentary slight contraction.

Seminal Vesicle. The responses are similar to those of the bladder. Adrenaline caused stimulation (Fig. III); repeated doses did not change the response. Ergotamine abolished the the adrenaline effect (Fig. IV), and there was no inhibition on subsequent injections of adrenaline.

The parasympathetic drugs (pilocarpine and atropine) had no effect.

QUANTITATIVE METHODS IN THE STUDY OF EARLY MAMMALIAN DEVELOPMENT. Donald Mainland, Dept. of Anatomy, Dalhousie Univ., Halifax, N. S. (Read Dec. 14, 1931). Quantitative methods are paramount in many of the biological sciences, and have been extremely productive there. The same class of method has been used in histology and embryology, but has not been so productive. This is largely because insufficient attention has been paid to the natural variation among the objects measured and to the errors due to methods of observation. Statistical tests must therefore be applied, especially those that have been developed for treatment of small samples. Some common criticisms of these tests are discussed. Instances are given of results obtained from quantitative studies of the ova of the ferret immediately after ovulation. These instances include the relationship of the fixative to the size of the chromatin particles in the pronuclei; the demonstration of cytoplasmic polarity; the numbers and positions of the polar bodies; the determination of the volumes and surface-areas of the pronuclei and of the volumes of the ova; the relationships of these measurements to each other and to other factors, such as the fixatives, the stage of development of the ova and their destiny.

THE SOLUBLE PROTEINS OF FISH MUSCLE IN RELATION TO MUSCULAR MOVEMENT AND TO RIGOR MORTIS. S. A. Beatty, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Feb. 8, 1932). Two proteins, one soluble in distilled water and with a minimum solubility pH 6.0, and the other soluble in salt solution and with a minimum solubility pH 5.0, were isolated from muscle of several species of fish. Evidence was given demonstrating the probability that the albumin is located in the isotropic segments, and the globulin in the anisotropic segments of the muscle. A theory of muscular movement and of rigor mortis was advanced based on a flow of water from the isotropic to the anisotropic segments as the result of known ionic changes in the muscle. This flow is possible because of differences in the physical and chemical properties of the proteins concerned.

THE MODE OF ACTION OF THE ANTHRAQUINONE PURGATIVES IN THE CAT.

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(Received January 23, 1933).

ABSTRACT.

Slightly alkaline extracts of aloes stimulate movement of the small and large intestine. Increased alkalinity increases the action of the drug. Absorption from the intestine is diminished by the anthraquinone purgatives. Neutral solutions are without effect.

The X-ray researches of Magnus[1], Stierlin[2], Meyer-Betz and Gebhardt[3] and others, have demonstrated that the purgative action of the anthraquinone derivatives is due entirely or almost entirely to their effect on the large intestine. The barium meal mixed with the purgative passes through the stomach and small intestine at the normal rate, but immediately on its entrance into the colon causes in that organ a marked activity which results after about half an hour in defaecation. Lenz[4] observed the movements of the gastrointestinal tract in cats provided with abdominal windows, and also found that senna and related purgatives acted on the large intestine. These experiments disproved the earlier theory of Hans Meyer[5], who believed that the delayed action of aloes was due to a gradual liberation of the active principle in the intestine. It is, however, possible that the drug is stable in the small intestine, and that conditions favouring the liberation of the active principle are met with only in the colon.

Several investigators[6,7] have found that aloin, senna, etc., strongly excite the isolated wall of both the large and small intestine. Such experiments show nothing of the normal mode of action of the purgatives, since the action of the drug when applied to the serous side of the wall may be quite different from its action when applied to the mucosal side. The majority of experiments on the intact intestine of animals with opened abdominal wall are likewise open to objection. For example, most of the observers (e. g. Nasse[8], Baeumker[9], Ott and Scott[10]) report pronounced action on the small as well as on the large intestine.

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[1] Magnus, *Arch. ges. Physiol.* **122,** 251 (1908).
[2] Stierlin, *Münch. med. Wochschr.* **1910,** 434.
[3] Meyer-Betz and Gebhardt, *Münch. med. Wochschr.* **1912,** 1773.
[4] Lenz, *Arch. inter. pharmacodynamie.* **28,** 75 (1923).
[5] H. Meyer, *Arch. exp. Path. Pharmakol.* **27,** 186 (1891).
[6] Hagena, *Diss.* Giessen. **1911.**
[7] MacCallum, *Univ. of Calif. Pub.* **1906,** p. 86.

It has been generally assumed that the anthraquinone derivatives, in contrast to the saline purgatives, have no direct action of the absorptive mechanism of the intestinal wall. The fluid character of the stood is explained as due to the shortened stay of the faeces in the colon and the consequent diminished absorption of water. Direct experiments to prove this point appear to have been carried out only on the small intestine, on which the drugs have normally no action. Baeumker[9] and Brieger[11] reported normal absorption in tied-off intestinal loops into which senna, aloes, etc. had been injected. Carnot and Glenard[12] on the other hand, perfused the surviving intestine with senna infusion and found increased transudation into the lumen. Increased secretion has also been described by MacCallum[7].

While it may be accepted as proved that the anthraquinone purgatives normally act mainly or entirely by stimulating the movements of the large intestine, there are some points of interest which can only be settled by acute experiments. Such questions are these: Is the restricted action on the large intestine due to the greater irritability of the large intestine wall, or to some change undergone by the drug in the colon? Is the increased peristalsis due to a direct action of the purgative on the intestinal musculature, or is it reflexly produced by irritation of the mucosa? Finally, is the fluid character of the stool due entirely to the decreased time given for absorption, or is there also some interference with the absorptive mechanism of the gut? In the experiments to be described it was endeavoured to secure at least partial answers to these questions.

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[8] Nasse, *Beitrage zur Physiologie der Darmbewegung.* Leipzig **1866.**
[9] Baeumker, *Diss.* Gottingen **1880.**
[10] Ott and Scott, Ott's *Contrib. to Physiol.* 18, no. 7, (**1909**).
[11] Brieger, *Arch. exp. Path. Pharmakol.* **8,** 355 (1878).
[12] Carnot and Glenard, *Compt. rend. soc. biol.* **74,** 120 (1913).

METHODS.

The drugs used were aloin, aloes, rhubarb, and cascara. As aloin alone of these is completely soluble in water, it was used in most of the experiments. The other drugs gave similar results in all cases in which they were used, and indeed no investigator has described qualitative differences in their action.

Cats were used in all the experiments, as resembling man in their digestive movements generally and in their response to the anthraquinone purgatives in particular[13]. Their diet contained considerable meat (aloin acts on cats only on protein feeding).

After some experimenting, the method of opening the abdomen in a warm saline bath, was used throughout. Besides preventing cooling and drying of the intestine, both of which cause abnormal motility, this method has the following advantages: (a) the movements can be observed directly ad oculos without disturbance; (b) the graphical record is not distorted by movements of the diaphragm and the underlying gut; (c) a nearly straight loop of intestine can be used, minimizing the excitation produced when the fluid within the loop is changed. Ringer's solution was used in most cases for the bath, but 0.9 per cent NaCl appeared to be equally satisfactory.

The animals were anaesthetized with chloralose (0.1 gm. per Kg.) given intravenously, and a tracheal cannula was inserted to prevent obstruction of the respiratory passages by mucus. Intestinal movements were recorded by the method of Babkin[14]. The abdomen was opened in the mid-line and a loop of intestine (duodenum, ileum, or ascending colon) 5-10 cm. long was selected. At each end of this loop a longitudinal incision 1-2 cm. long was made through both layers of muscle along a line opposite to the mesentery, and the muscle was carefully separated by means of a blunt instrument from the submucosa. Two ligatures were then passed around the loop at each incision between the muscle and the mucosa. One of these was used to tie off the intestine beyond the loop selected; the other was used to secure a glass tube whose end was inserted into the lumen through an incision in the mucosa. A T-tube was used at the lower end of the loop, a straight tube at the upper end. (See diagram). The T-tube was connected by means of rubber tubing to an outlet Tap T_2 set into the side of the bath, and also to a graduated glass bulb which was in turn connected to a recording tambour. In this way there was no interference with the blood and nerve supply to the loop. In the colon the procedure of separating the muscle from the mucosa is more difficult, and in most of the experiments the less desirable method was adopted of securing the tubes by means of ligatures passed around the undissected gut.

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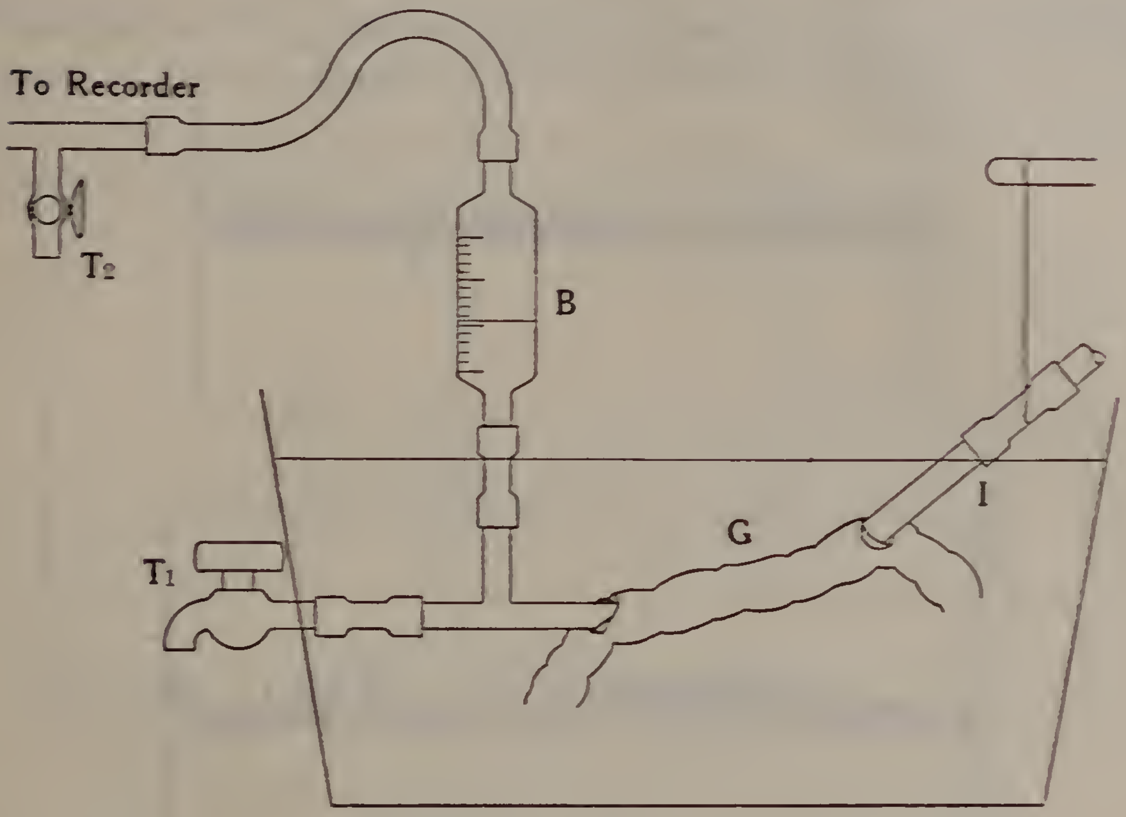
[13] Magnus, *Anthrachinonderivate*, Heffter's *Handbuch der experimentelle Pharmakologie*, 2er Band, 2 Halfte. Springer, Berlin, **1924**.

[14] Babkin, *Die äussere Sekretion der Verdauungsdrusen.* Springer, Berlin. **1928**. 2nd ed., p. 845.

The loop was gently washed through with warm saline from a syringe, and the excess saline removed by gentle blowing of air through the loop. Fluid of the desired composition, carefully adjusted to body temperature, was then introduced from the syringe, the outlet tap being closed, until the fluid reached a suitable height in the bulb (4-5 cm. above the level of the bath). The quantity injected was noted, and the same volume used when the fluid was replaced. Precautions were taken to keep the temperature of the bath constant to within 0.1°C., to keep the loop at a constant depth below the surface of the bath, and to avoid the introduction of air bubbles into the loop. The adjustment tap T_2 was closed when the fluid reached a definite height in the bulb B; in this way it was possible to observe variations in the tone of the loop after changing the fluid. To withdraw the fluid, taps T_1 and T_2 were opened and the loop was gently blown through with air from a syringe. Much care was necessary in this operation to avoid extraneous stimulation caused by stretching of the gut. The graphic record was continually checked by naked eye inspection.



B, bulb; G, loop of gut; I, inlet tube; T_1, outlet tap; T_2, adjustment tap.
DIAGRAM SHOWING ARRANGEMENT OF APPARATUS.

Absorption was measured directly by introducing a known volume of fluid, permitting it to remain in the loop for a fixed period (e. g. 30 minutes), and measuring the volume withdrawn. This gives values or the volume absorbed, accurate to about 10 percent, which is sufficient. No attempt was made to distinguish between absorption and secretion.

EXPERIMENTAL RESULTS.

A considerable number of experiments were performed to see if aloin could act on the small intestine. A loop of duodenum or ileum was filled with a 0.1% or 1% solution of aloin in 0.9% NaCl, and movements and absorption compared with a period of equal length during which the loop was filled with saline alone. Such preparations of aloin were uniformly found to be without effect on the motility of the loop (Fig. 1). There was generally a slight decrease of absorption, especially with the stronger solutions; this decrease is probably to be ascribed to the somewhat increased osmotic pressure of the fluid; it was never very great, and sometimes was entirely absent. One experiment may be quoted to illustrate the results obtained.

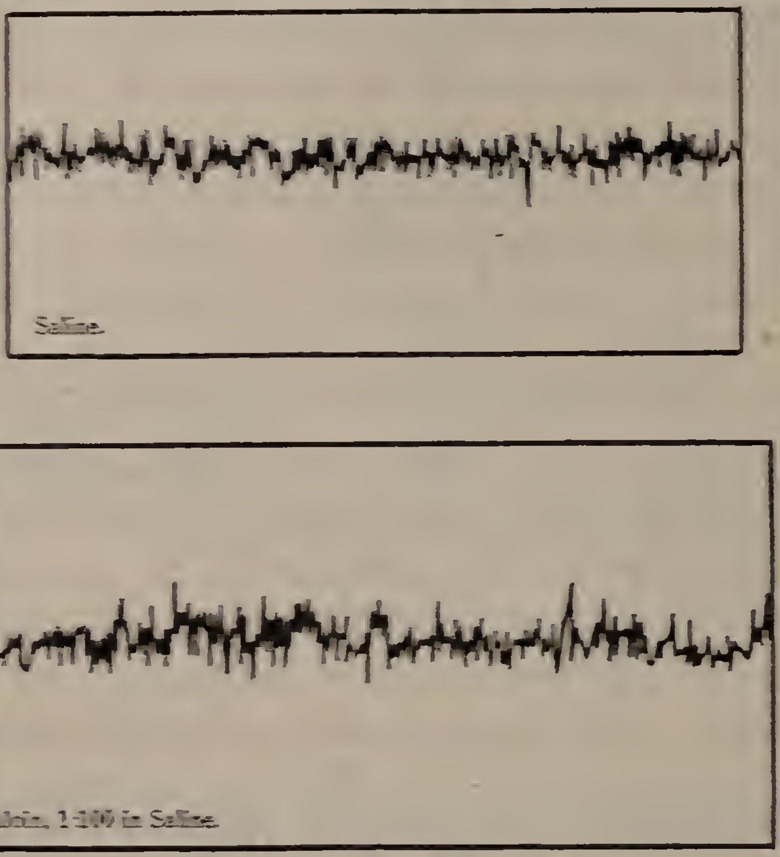


Fig. I. Duodenum.

Loop of Duodenum, length 8 cm.

Fluid	Volume introduced	Volume withdrawn	Length of period	Absorption
Saline	18 cc.	16.0cc.	20 min.	2.0 cc.
Saline	18	15.9	do	2.1
Aloin 1:1,000	18	16.2	do	1.8
Aloin 1:100	18	16.6	do	1.4
Saline	18	16.3	do	1.7

When Ringer's solution containing 0.05 percent $NaHCO_3$ was used instead of 0.9 percent NaCl, varying results were obtained. In one or two experiments there was a definite stimulation of peristalsis, but in others this was either doubtful or absent. As before, there was no constant effect on absorption.

Curiously enough, neutral solutions of aloin were found to act on loops of colon in exactly the same way. Such solutions neither excited the movements of the large intestine nor caused any appreciable diminution in the amount of fluid absorbed (Fig. II). In one experiment in which the faeca matter had been completely washed out of the loop, there did appear to be a considerable stimulation of peristalsis, accompanied by transudation into the lumen. In twelve other experiments, however, no such action was seen.

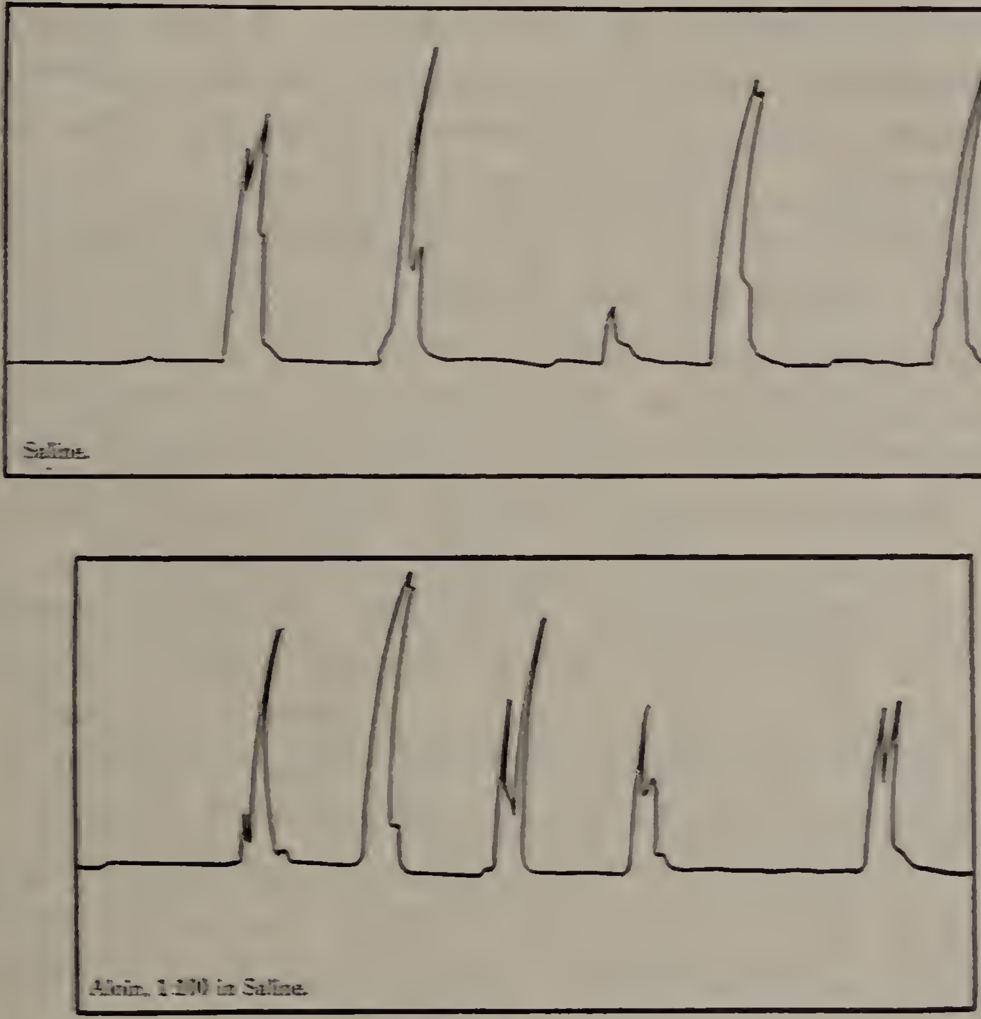


Fig. II. Colon.

These results strongly suggest that the reason why aloin fails to act on the small intestine under normal circumstances is because the drug as given is inert, and is only converted to the active form under the conditions prevailing in the large intestine. It thus becomes of interest to know what conditions are responsible for this "activation" of aloin.

In this regard, it is to be pointed out that one of the most striking characteristics of aloin, and of the anthraquionne derivatives generally, is their reaction to alkalies. The yellow or brown neutral solutions of the drugs on addition of a alkali become bright red in colour, the change taking place slowly (e. g. 10-20 minutes) if the alkalinity is very slight, instantaneously in strongly alkaline solutions. The chemistry of the change is not understood, but probably involves an hydrolysis of the glucosides of which the drug is mainly composed, with liberation of free anthraquinone derivatives like emodin (trihydroxymethylanthraquinone) and chrysophanic acid (dihydroxymethylanthraquinone). These substances combine with the base to form bright red salts, there being probably some associated tautomeric change in the anthraquinone molecule. The reaction is reversible. It has been shown by MacClendon[15,16,17] that the small intestinal contents of man and animals are not alkaline in reaction, as has been generally supposed, but definitely acid (pH 5.6-6.6 in ileum of dogs). Unfortunately no direct data on the reaction of the large intestinal contents could be found in the literature. The faeces of man are normally slightly alkaline (pH 7.0-7.5)[18,19]. London[20] found that the material escaping from a caecal fistula was strongly alkaline in reaction. It is easy to suppose that intestinal putrefaction could cause an alkaline reaction, if the easily diffusible acid products of protein deaminization are absorbed, while the slowly diffusible basic products of decarboxylation accumulate in the lumen of the colon. The possibility is therefore to be considered that the red alkaline form of aloin only is active, and this is formed in the large but not in the small intestine. In this connection it is interesting to remember that, as pointed out above, aloin acts on cats only when protein is fed.

The testing of this hypothesis was made difficult by the fact that the intestinal musculature is very sensitive to the reaction of the fluid which bathes it. Dilute acid relaxes and dilute alkali stimulates it. Excised intestinal muscle, for example, is thrown into a strong contraction if the pH of the solution in which it is suspended is changed from 7.0 to 8.0.

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[15] McClendon, *J. Am. Med. Assoc.* **75**, 1638 (1920).
[16] McClendon, *J. Biol. Chem.* **38**, 535 (1919).
[17] McClendon, *ibid.* **34**, 1 (1916).
[18] Howe and Hawk, *J. Biol. Chem.*, **11**, 129 (1912).
[19] Robinson, *J. Biol. Chem.*, **52**, 445 (1922).
[20] London (quoted by Starling, *Human Physiology*, 5th ed. p. 613, Lea and Febiger, Philadelphia, **1930**).

Changes of hydrogen ion concentration on the mucosal side of the gut have much less effect, as is sufficiently evident from the case of the stomach. The introduction of slightly alkaline solutions into the lumen of the intestine does, however, considerably stimulate motility, either through diffusion of alkali into the muscle or reflexly through irritation of the mucosa. The problem thus is to compare the action of alkaline solutions of aloin with that of isotonic fluids of the same reactions.

Several sorts of alkaline solution were used for this purpose: (a) isotonic (1.3%) $NaHCO_3$, pH about 9.0; (b) sodium borate-boric acid solution of pH about 8.5; (c) in some experiments N/1,000 NaOH was added until the solution was just alkaline to phenolphthalein (pH about 8.5). Of these the most satisfactory was the borate buffer solution, and it was used in most of the experiments. As compared with 0.9% NaCl, all these solutions stimulated the intestine to some extent. Solutions more alkaline than pH 9.0 were strongly stimulant and damaged the mucosa considerably.

When aloin is added to such solutions it exerts a considerable buffering action, and the alkalinity is reduced. It was found, nevertheless, that the addition of aloin to such alkaline solutions greatly increased their activity on the intestinal musculature of both the large and the small intestine (Figs. III, IV, V). The stimulation was characterized by increased frequency and force of the peristaltic movements, inflammation and sloughing off of the mucosa, marked secretion of mucus (especially in the colon), and decreased absorption. In many cases, especially when the fluid contained 1 percent of aloin, there was transudation of fluid into the lumen, and the volume of the fluid withdrawn exceeded that introduced. There was tendency to colicky spasm of the gut, which sometimes contracted so forcibly that the vessels of the wall were squeezed empty of blood. Sometimes, especially in the colon periods of intense activity lasting two or three minutes alternated with periods during which the gut was inactive. There was usually a latent period of 20-30 minutes before the aloin action became marked. Shedding of the mucosa was a very characteristic feature; it came off in large patches, dyed by the aloin solution. The stimulation persisted for hours after the purgative was thoroughly washed out of the loop, suggesting that reflex irritation caused by the damage to the mucosa was a factor in the stimulation.

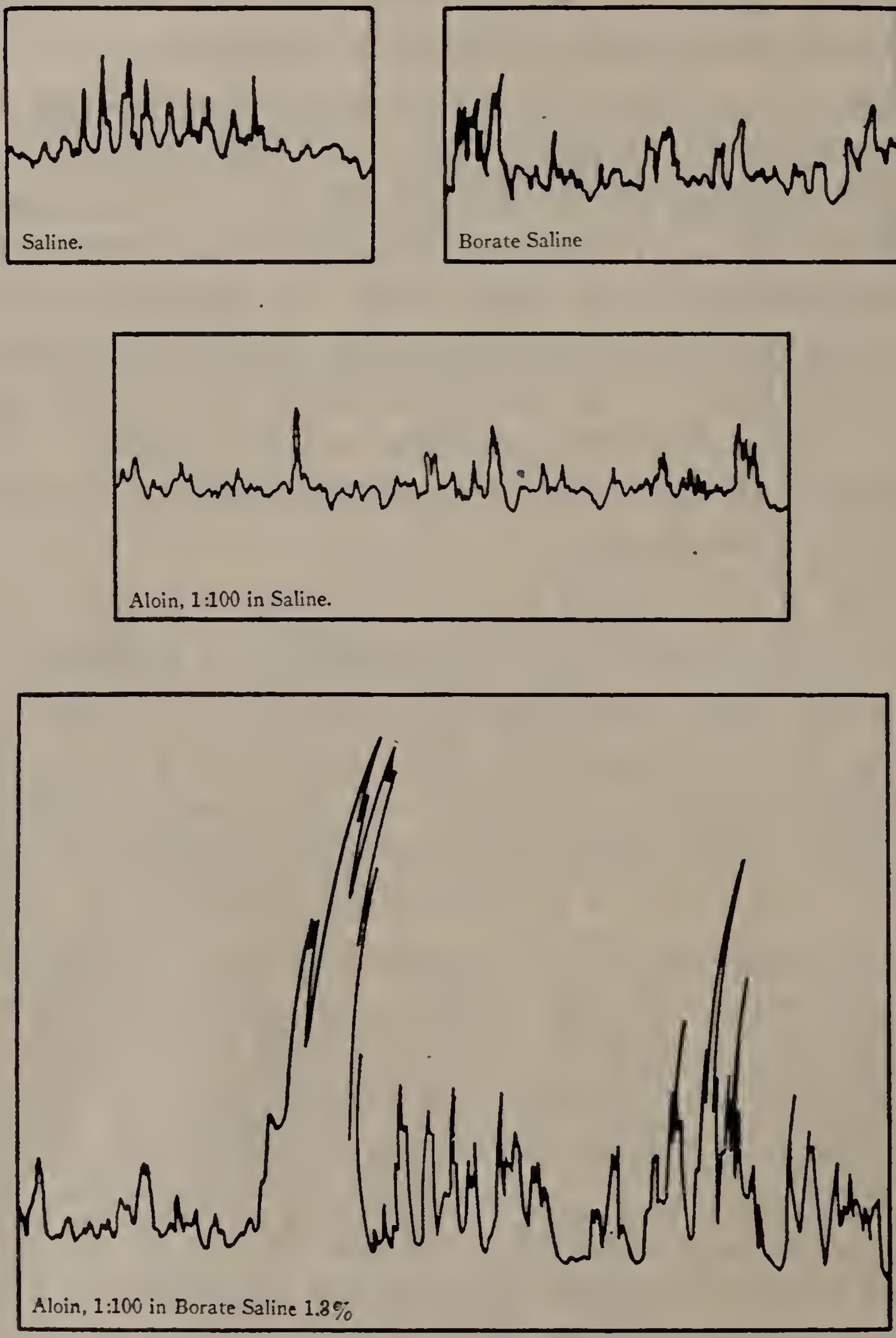


Fig. III. Ileum.

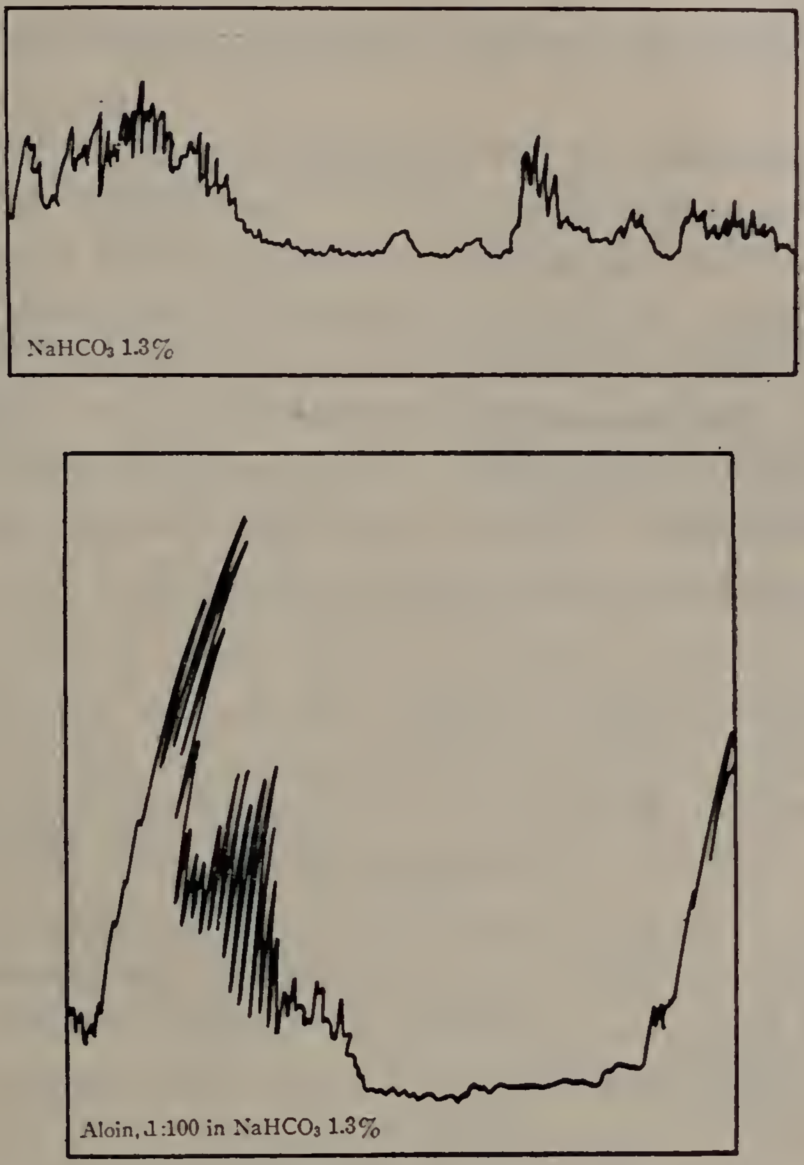


Fig. IV. Ileum.

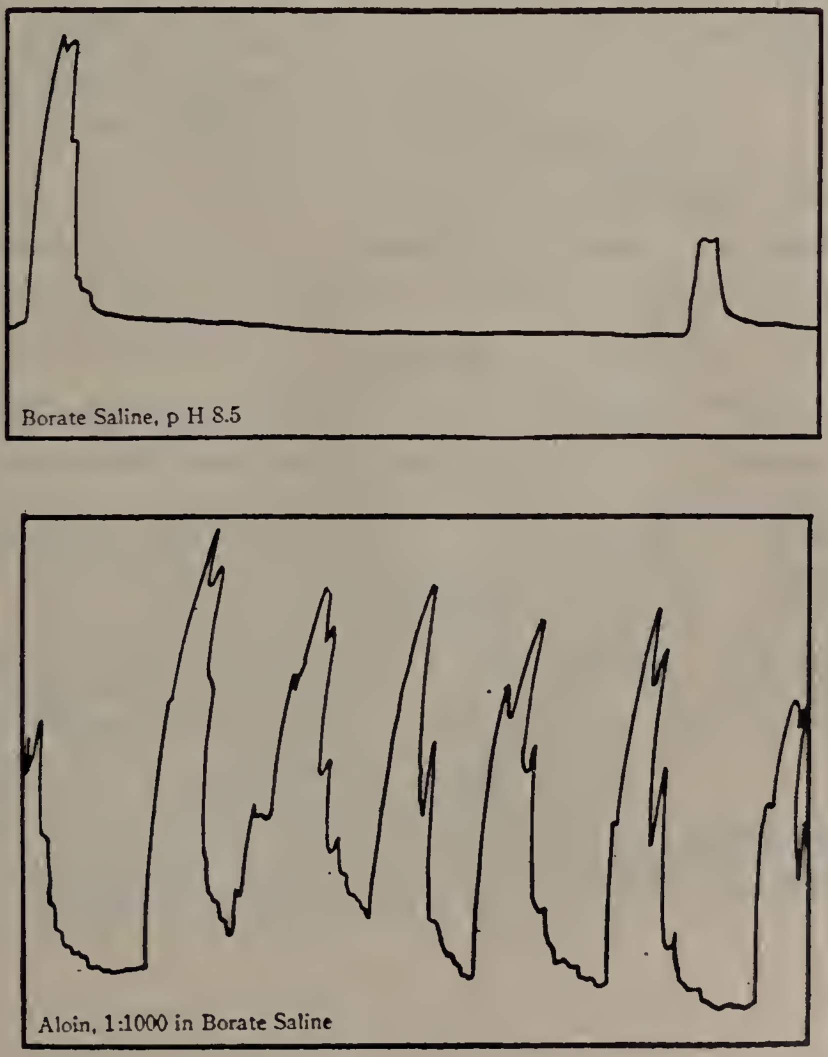


Fig. V. Colon.

In a few cases the increased motility did not take the form of peristalsis, as was expected, but of antiperistalsis, which was, however, far more powerful than the normal type seen in the proximal colon. It must be supposed that the direction of the movements was reversed by the obstruction of the lower end of the loop. In the majority of cases, however, the stimulation was featured by peristalsis, and frequently also by spasm of the circular coat. One or two typical experiments may be quoted to show the type of result obtained.

ILEUM.

Time	Fluid	Intr.	Withdr.	Movements.
11.44	Saline	20 cc.		Small movements, chiefly of lonigtudinal coat, with slow variations of tone.
11.14			18.0 cc.	
11.22	Borate saline.	20 cc.		Slight stimulation, rapidly falling off after 3-4 minutes.
11.52	pH 8.5		18.5 cc.	Remainder as above.
(Loop washed out)				
11.55	Aloin .1%	20 cc.		As in previous period.
12.25	in saline		18.6 cc.	
12.29	Aloin .1% in borate saline	20 cc.		No stimulation for 15 min., then sudden onset of vigorous peristalsis, with tendency to spasm, persisting to end of period
12.59			21.2 cc.	Much mucosa withdrawn.

ASCENDING COLON.

Time	Fluid	Intr.	Withdr.	Movements.
11.00	Saline	16 cc.		Occasional shallow antiperistalsis.
11.55			14.4 cc.	
12.00	Aloin 1%	16 cc.		2-3 larger movements during 1st half hour, then quiet.
12.55	in saline		14.8 cc.	
(Loop washed out)				
1.00	Borate saline	16 cc.		Gut quite idle throughout.
1.55	pH 8.5		14.9 cc.	
2.00	Aloin 1% in borate	16 cc.		No movements for 10 min., then gentle antiperistalsis changing to powerful peristalsis, lasting till end of period. Withdrew much mucosa.
2.55			20.0 cc.	
(Gut washed out)				
3.00	Saline	16 cc.		Persisting powerful peristalsis, falling off somewhat towards end.
3.55			18.0 cc.	

ASCENDING COLON.

Time	Fluid	Intr.	Withdr.	Movements.
3.38	Saline	14 cc.		A few fairly large antiperistaltic
3.58	0.9%		10.6 cc.	movements.
4.00	.45% NaCl —.65%	14 cc.		Increase in frequency, slight increase in force. Antiperistalsis.
4.30	$NaHCO_3$		11.5 cc.	No mucosa withdrawn.
4.35	Aloin 1% in above	14 cc.		Strong peristalsis, with tendency to spasm, increasing during 1st
5.35			13.8 cc.	half hour, persisting to end.

One experiment may be described which would appear to show that the irritation of the mucosa is the factor chiefly responsible for the stimulation. A loop of large intestine which had been stimulated in the typical way by an aloin solution was washed out with saline, and the aloin replaced by a suspension of procaine, made by adding NaOH to a 1% solution of procaine hydrochloride until there was no further precipitation. The procaine suspension, probably on account of its alkalinity, strongly stimulated the gut. After 3 minutes it was withdrawn, and the loop was washed out and refilled with alkaline aloin solution. The loop thereupon became quite quiet and remained in that condition. It is of course possible that sufficient procaine might have penetrated to the muscular coat to paralyze Auerbach's plexus, though this is highly improbable because of the insolubility of the procaine base.

If aloin in neutral solution is permitted to stand exposed to the air, it becomes much darker in colour, but does not exhibit the typical deep red hue of alkaline solutions. A few experiments were performed to see if this ageing increased the activity of the aloin. The results obtained were somewhat contradictory. A stimulation was found in one out of three experiments on the ileum, and in one out of two experiments on the ascending colon, in which aloin solutions 1-2 weeks old were used. The stimulation was accompanied, as in the preceding experiments, by decreased absorption and damage to the mucosa. The darkening is presumably due to oxidation, but the chemistry of the change is unknown.

In view of the assertion made by Buchheim and others that the anthraquinone purgatives act only in the presence of bile, one or two experiments were performed in which the aloin was dissolved in a neutral solution of 2% dried ox-bile. No stimulation was produced on either the large or the small intestine (Fig. VI). The theory of Buchheim was at any rate disproved by Stadelmann, who found that aloes, aloin, senna, and rhubarb caused normal purgation in a dog equipped with a complete biliary fistula. As the bile salts, which would presumably be the active factor, are absorbed almost completely in the small intestine, these results are not surprising. It is possible that bile may promote purgative action by increasing the alkaline reserve of the contents of the large intestine.

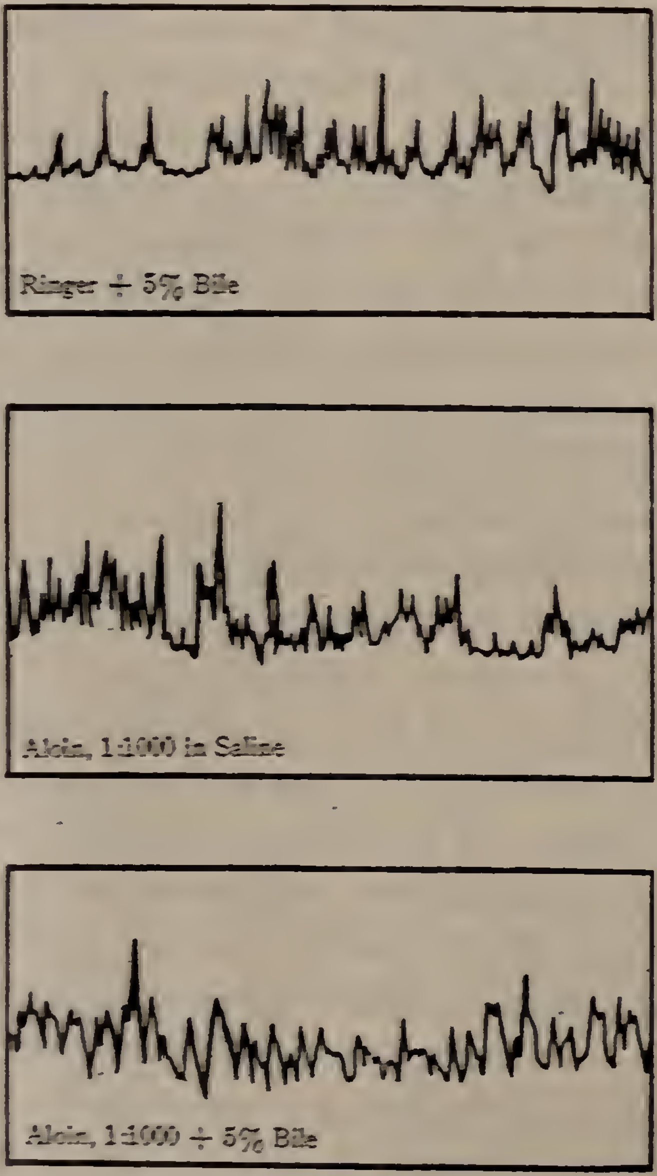


Fig. VI. Duodenum.

These experimental results may be briefly summarized and interpreted.

Fresh neutral solutions of aloin are without action on either the small or the large intestine. Alkaline solutions, however, act strongly on all parts of the intestinal tract, and the action is greater than can be accounted for by the alkalinity alone. There is evidence that the contents of the colon are more alkaline in reaction than the contents of the small intestine, and it seems probable that this is at least one reason for the fact that the anthraquinone purgatives normally act on the large intestine alone.

Ageing of aloin solutions also appears to increase their activity, and it is possible that various processes taking place in the large intestine may assist in the "activation" of the drug. In any case, the fact that the purgative action is normally confined to the colon is to be explained as due to a change undergone there by the drug itself, not to any peculiar sensitivity of the wall of the large intestine.

The purgative action appears to be due mainly to increased peristalsis, but secondarily to inhibition of the absorptive mechanism of the colon. The fluid character of the stool is thus due partly to this inhibition and partly to the decreased time given for absorption. The stimulation of motility is always accompanied by increased secretion of mucus and by damage to the mucosa. It is therefore likely that the augmented motor activity depends on a local reflex mechanism set in action by this irritation of the mucosa.

FURTHER OBSERVATIONS OF THE INFLUENCE OF ELECTROLYTES ON THE FORMATION AND DECOMPOSITION OF URATE GELS. E. Gordon Young and Harvey C. Graham, Dept. of Biochemistry, Dalhousie Univ. (Read March 14, 1932). The influence of electrolytes in promoting gelation of solutions of methyl amine urate has been extended and confirmed with solutions of lithium urate. The chlorides of potassium, ammonium, sodium and lithium have been used and their potency has been found to decrense in the order named. An optimal concentration exists for each electrolyte at which the gel is most stable and most quickly formed. At the upper limit of electrolyte at which gels will form it has been found that crystallization of the gel is accelerated.

PRESIDENTIAL ADDRESS.

E. Gordon Young.

(Read October 14, 1931).

This occasion marks the close of the sixty-ninth annual session and the beginning of the seventieth. It is fitting that at this time the president should be required to give an account of his stewardship during the year and that he should link the achievements of the past with the problems of the future.

During the course of the year the Institute has suffered a loss by death of one of its members. On February 14th, 1931, there occurred the tragic death of one of our young student members due to a toxaemia subsequent to severe burns received in an accident in the organic chemical laboratory of Dalhousie University. Hugh Graeme Fraser was in his fourth year of the honours course in chemistry and looking forward to a professional life in that subject. All those who knew him testify to his admirable personal qualities and his devotion to science.

The Institute has also suffered a loss in the departure of its former president, Dr. Douglas MacIntosh, from Halifax to Shawinigan Falls, Quebec. Our good wishes follow him there as well as our thanks for his years of admirable and exemplary service to the society.

In order to enhance the dividend return on moneys invested in a savings account with the Bank of Nova Scotia the council authorized the purchase of a $500 Victory Bond maturing in 1934 bearing interest at the rate of five and a half percent. This was later in the year converted into an equivalent bond in the Conversion Loan of maturity 1959 at four and one-half percent interest.

A new form of membership was established by the following minute of the last annual meeting.

> "Resolved that students in any educational institution be allowed to join the Nova Scotian Institute of Science as student members with a fee of one dollar but without vote."

We have thus created a membership equivalent to that of associate membership but open only to a restricted group which we wish to encourage in the pursuit of science. Twenty-one individuals were elected to membership by the council on this regulation. The membership of the Institute was otherwise well maintained. Seven ordinary and three associate members were elected. Our total enrollment now stands at about 100. It is not an exaggeration to state that in so far as professional scientists are concerned our roll carries the names of most of those in the province.

Our Editor, Dr. H. S. King, has given much thought to ways and means of facilitating the publication of the Proceedings. Certain changes have been adopted by way of reducing the cost of publication and accelerating the printing of original articles during the year. In order to accomplish this it has been found necessary to change the sequence of material. Papers published in full will have precedence in the order of their acceptance. These will be followed by papers published in abstract, then condensed reports of business and ordinary meetings. This should facilitate printing of original articles as soon as received and the delivery of separates to the author before the appearance of the part. The term "Transactions" has been omitted from the title because of the new order of material and because of the arbitrary division between Proceedings and Transactions previously recognized but now abolished.

It is a source of gratification to your executive that the main purpose of the Institute has been served in that the promotion of research has been its only activity and that the number and quality of original papers presented has been well maintained. The number of papers read before the society this year was fifteen. Classified according to the different branches of science there were nine chemical papers, four biological, (two zoological and two pharmacological), one physical and one meteorological. A very small proportion of those read before the society will appear in the Proceedings. And it is anticipated that this state of affairs will continue for various reasons. This is the most important issue before the society at the present time.

The encouragement of research into provincial and maritime problems is, I venture to state, one of the functions of this Institute. The systematic paper on the flora and fauna of this province has disappeared entirely from our publication. This is regrettable and deserves a careful study by the new executive and the society as a whole.

May I be permitted to take this opportunity of thanking the members for the honour which they have done me in entrusting to me the chairmanship of the society. I would also express my thanks to the members of the council for their generous co-operation at all times.

PROCEEDINGS OF MEETINGS.

SESSION OF 1931-32.

(*All meetings were held in the Medical Science Building, Halifax*).

70th Annual Business Meeting, Oct. 14, 1931.—The President, Dr. E. G. Young, in the chair. Others present: D. J. Matheson, Dr. H. R. Chipman, Dr. H. S. King, Prof. G. A. Burbidge, Dr. G. H. Henderson, Capt. W. F. Mitchell, Prof. R. J. Bean, Prof. W. P. Copp, Prof. E. Hess, Dr. J. H. L. Johnstone, Prof. C. B. Nickerson, Dr. S. G. Ritchie, and H. Piers.

The President delivered an address dealing with the progress of the society during the past session. Attention was drawn to the death of Prof. W. F. MacKnight and Hugh Graham Fraser. The Treasurer's report showed that the receipts for the past year were $2,148.75; expenditure, $1,247.68; balance in current account, $901.37; reserve fund, $718.84; and permanent endowment fund, $1,500.00. The Librarians report showed that during the year ended Sept. 30, 1931, 2,031 books and pamphlets had been received through the Institute's exchange-list; and the total number in its library on that date was 62,901. The number of accessions of the entire Provincial Science Library (with which that of the society is incorporated) in the same period was 2,302; and the total number in the Library on Sept. 30, 1930, was 82,613. During the year 264 books were borrowed. Reports were also presented by the Corresponding Secretary and the Editor of the Proceedings.

Rev. Bro. Cornelia was congratulated on his appointment to the principalship of St. Mary's College.

The following were elected officers for the year 1931-32: *President*, Prof. E. G. Young, Ph. D.; *vice-presidents*, Prof. D. S. McIntosh, M. Sc., A. H. Leim, Ph. D.; *treasurer*, D. J. Matheson, B. Sc.; *corresponding secretary*, Prof. E. Hess; *recording secretary and librarian*, H. Piers; *councillors without office*, Prof. H. S. King, Ph. D., Prof. G. A. Burbidge, Prof. G. H. Henderson, Ph. D., D. J. MacKenzie, M. D., Capt. W. F. Mitchell, Rev. Bro. W. Cornelia, and Prof. N. B. Dreyer, M. R. C. P.; *Auditors*, P. R. Colpitt and Prof. W. P Copp, B. Sc.

Dr. Young and Dr. Johnstone were nominated as the Institute's representatives on the Provincial Science Library Commission.

Votes of thanks were presented to the treasurer, Mr. Matheson, to the retiring corresponding secretary, Dr. Chipman, and to the recording secretary, Mr. Piers.

1*st. Ordinary Meeting, Nov.* 9, 1930.—It was announced that on Oct. 26, Dr. D. McIntosh has been elected a corresponding member; Dr. M. Jacobson and Dr. R. Morash, ordinary members; and Dr. A. R. Prince, an associate. A committee appointed on Oct. 26 to consider the question of popular lectures, recommended "that the Institute do not undertake to furnish lectures for the general public or for high school students, but that the occasional presentation of papers or lectures on matters of general scientific interest, at the regular meetings of the Institute be favourably considered and that two such papers or lectures be provided for this winter." The committee was authorized to arrange a programme as recommended. A. F. Chaisson, Ph. D., presented a paper on "The Effect of Destruction of the Spinal Cord on Osmotic Control in Elasmobranches"; and Dr. H. L. Bronson gave a brief account of the London meeting of the British Association for the Advancement of Science, of the Faraday Celebration, the Royal Institution, the Maxwell Celebration in Cambridge and the Cavendish Laboratories.

2*nd Meeting, Dec.* 14, 1931.—Prof. H. P. Bell, presented a paper on "The Algal Flora of Hudson Bay;" and D. Mainland, one on "Quantitative Methods in the Study of Early Mammalian Development."

Popular Lecture, Jan. 11, 1932.—It was announced that Miss D. Pelluet, Ph. D., Halifax, had been elected an ordinary member on Jan. 4th. Prof. F. R. Hayes, delivered a popular lecture on "The Life of the Salmon."

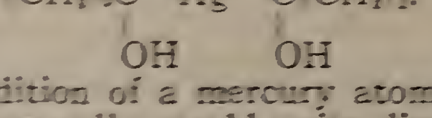
3*rd Meeting Feb.* 8 1932.—It was announced that Hon. Mr. Justice Mellish had been elected an ordinary member on Jan. 25th. Miss C. MacFarlane presented a paper on "Seasonal Changes occurring in the Marine Algal in the Vicinity of Halifax"; and S. A. Beattie, on "The Proteins of Fish Muscle and their possible Relation to Muscular Movement and Rigor."

4*th Meeting, Mar.* 14, 1932.—It was announced that C. H. Connolly, Halifax, had been elected an ordinary member on Feb. 29th. Prof. E. G. Young, and H. C. Graham, presented "Further Observations of the Influence of Electrolytes on the Formation and Decomposition of Urate Gels", and E. Hess a paper on "Bacterial and Chemical Changes in Canned Lobster."

5th Meeting, Apr. 11, 1932.—S. Bateson presented a paper on "Pleochroic Halves in Biotite"; and R. A. Morash, and F. C. MacIntosh, one on "Responses of the Rat's Bladder, Seminal Vesicle and Vas Deferens."

6th Meeting, May 11, 1932.—It was recorded that the Institute learns with deep regret of the death of its senior corresponding member and oldest surviving member, the Rev. Charles James Stewart Bethune, D. C. L., F. R. S. C., a highly distinguished entomologist and educationist, which sad event took place at Toronto, Ont., on Apr. 18, 1932, in his ninety-fourth year. He was elected a corresponding member of the Institute on Dec. 29, 1868, and prepared a list of Nova Scotian Lepidoptera, with notes by J. M. Jones, which appeared in the Transactions, Vol. 2, p. 78 (1869), and he also identified nearly all the Nova Scotian Coloptera included in Mr. Jones's list published in the same volume, p. 141. C. R. K. Allen, presented a paper on "Physical Changes in the Early Development of the Salmon"; F. C. MacIntosh, one on "The Action of Some Anthraquinone Purgatives on the Intestine," and J. F. Horwood and Prof. H. S. King, one on "An Organo-Mercury Compound Formed in Pinacol Reduction."

Harry Piers,
Recording Secretary.

AN ORGANO-MERCURY COMPOUND FORMED IN PINACOL REDUCTION. J. F. Horwood and Harold S. King, Dept. of Chem., Dalhousie Univ., Halifax, N. S. (Read May 11, 1932). In the preparation of pinacol hydrate by the reduction of acetone with magnesium in the presence of a benzene solution of mercuric chloride, an organo-mercury compound is formed in small quantities. This compound is a non-volatile, syrupy liquid, soluble in benzene and in water. It decomposes at about 130° with liberation of metallic mercury and water. With dilute hydrochloric acid it gives no precipitate, therefore does not contain the C-Hg-OH group. Heated with mercuric chloride solution, it forms a yellowish precipitate, therefore it may contain the C-Hg-C group. This precipitate is insoluble in benzene, water, acetone, etc., but soluble in aniline. It decomposes at 136-137°. A benzene solution of acetone reduced by magnesium amalgam yields a similar liquid which, with mercuric chloride, gives a precipitate evidently identical with that mentioned above. It also decomposes at 136-137°. Since the liquid organo-mercury compound is difficult to purify, only inconclusive analyses were obtained. The following provisional formula is suggested:  $(CH_3)_2\underset{OH}{\underset{|}{C}}—Hg—\underset{OH}{\underset{|}{C}}(CH_3)_2$. Its formation would be explained by the addition of a mercury atom between the two trivalent carbon atoms which normally would unite directly together to yield pinacol.

Bacterial and Chemical Changes in Canned Lobster. Ernest Hess, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read March 14, 1932). Formation of *Iron sulfide* ("black discoloration" of can and meat) is known to be caused through liberation of volatile S from lobster meat by bacterial action in non-sterile cans, or in boiled meat during incipient decomposition before canning, together with the corrosion of the tin lining of the can, thus allowing the S to react with the iron body of the can. Observed in cans within pH range 6.7 to 7.7 (in test tube, reaction occurs at pH 6.65 and higher), in contrast to data of Japanese workers on canned crab: black discoloration only at pH 7.5 and higher. Iron sulfide observed in sterile cans, packed and sterilized immediately after boiling of live lobsters, led to investigation of effect of vitality of live lobsters at time of boiling on iron sulfide formation in the cans. Increasing period of keeping live lobsters on ice, previous to boiling and canning, led to increase of pH of can contents (from pH 6.9 to 7.7) and increased black discoloration (after 13 months' storage). Determination of pH of body fluid of live lobsters, kept on ice, showed slight increase in first 24 hours (from pH 7.1 to 7.3), followed by decrease when lobsters lost vitality (became "sick") and second decrease immediately after lobsters died (lactic acid production). Lobster meat packed at this latter stage gave a can with pH 6.3 and showed no iron sulfide after 13 months' storage. No correlation observed by other workers between amount of volatile S in meat and length of time live lobsters kept on ice. Formation of crystals of *Magnesium ammonium phosphate*, observed in sterile cans within pH range of 6.5 to 7.7, especially in cans showing much iron sulfide formation (pH 7.1 to 7.7). Precipitation of crystals from natural constituents of lobster meat in lkaline medium. Crystal formation also observed in bacterial stab cultures in media containing lobster meat infusion, especially at slightly alkaline reaction (pH 7.4) at incubation temperatures from 5° to 37°C. Amount of crystal formation in cans increases with age of cans at storage temperatures from O° to 35°C. Formation of *Blue-Green Discoloration*, in coagulatedlood in cans,little investigated. Copper occurring in lobster blood (in place of iron in mammalian blood). Formation of Ammonia Cupric salt (Fellers and Park) not likely, as reaction in cans hardly alkaline enough for this reaction. Observed in cans with pH 6.9 to 7.35. Other compounds of copper (with Cl, S, As, PO_4 etc.) possible, as all these elements occur in canned lobster.

Pleochroic Haloes in Biotite. Sydney Bateson, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read April 11, 1932). Pleochroic haloes in biotite have been studied quantitatively. The intensity of discolouration has been measured directly by a microphotometer. The resulting photometer curve shows close agreement with the integrated ionization curve for the Uranium family.

NOTICE TO AUTHORS.

To be printed in the volume of the year, a paper must be submitted for publication on or before the date of the May meeting.

Manuscripts should be typewritten (double spaced) on one side of the paper, 8½x11 inches, with 1 to 1½ inch margins. The original typewritten copy should be furnished.

An abstract, not over 200 words in length, must be placed at the beginning of the article. It should be suitable for reproduction in abstract journals. As an index, it should be complete; all the subjects, major and minor, concerning which new information is presented, should be mentioned. As a summary, the abstract should give briefly the conclusions of the article, important advances in experimental technique and in theory, and numerical results of general interest. For an excellent type of abstract see "The Physical Review." A summary at the end of the article should be omitted since it is included in the abstract.

Citations to the literature and notes will be placed at the bottom of the page and should be indicated in the text by superscript numerals, numbered consecutively from 1 up. All footnotes should be collected on a separate manuscript page for the benefit of the printer. The form of citations should be as indicated by the following examples:

[1]Thomson, *Phil. Mag.*, [7] **3**, 241 (1927).

[2]Bachem, *Arch. exptl. Path. Pharm.*, **122**, 69-76(1927); *C. A.*, **22**, 274 (1928). No reference should be cited which has not been consulted by the author himself. When only an abstract is available, it should be indicated in the citation as in the second case above. In abbreviating journal titles employ standard abbreviations used in such well-known abstract journals as "Chemical Abstracts." In citing books, use the form shown in the following example:

[3]Mellor. "*Inorganic and Theoretical Chemistry*," Longmans, Green and Co., London. **1923**. vol. 4, pp. 625, 645.

In constructing tables arrange them to leave as little waste space as possible. All drawings intended for reproduction should be made about twice the size of the proposed cut on white paper. They should be drawn with extreme care, preferably by a draftsman. Material in each figure should be arranged compactly. It is well where possible to make the longer dimension horizontal. All lines that are to be reproduced must be sufficiently heavy to be clearly legible in the finished cut. When coordinate paper is used, it should be printed in blue only, with the important lines ruled over in black; the black squares in general should be not less than ten millimeters on a side in the printed cut. The lettering of cuts, when reduced, should be about the size of the letters in the text. Where necessary half-tones for reproduction on special paper will be accepted.

Unless page proofs are specifically asked for galley proofs only are sent to the author for correction. Proofs should be corrected with great care and returned by next mail to the Editor, Dr. Harold S. King, Dalhousie University, Halifax. N. S.

The Institute furnishes the author of each paper with 50 reprints without covers gratis. Additional copies may be obtained at reasonable rates if applied for at the time of return of the proof to the Editor. If covers to reprints are desired, an extra charge is made.

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HALIFAX, NOVA SCOTIA

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Editor: HAROLD S. KING

Editorial Board: J. H. L. Johnstone, E. G. Young, and H. R. Chipman.

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PROCEEDINGS

OF THE

Nova Scotian Institute of Science

SESSION OF 1932-33
(Vol. XVIII, Part III)

NOTE ON A RARE PHENOMENON IN THE NIGHT SKY.

A. G. HATCHER.

Memorial University College, St. John's, Newfoundland.

(Received July 15, 1932).

ABSTRACT.

A narrow belt of light extending across the sky, east and west, was seen at St. John's, Nfld., on the evening of April 25, 1932. It may have been an unusual form, either of aurora or of zodiacal light.

At St. John's, Newfoundland, between the hours of 9 and 11 of the evening of April 25th, 1932, a very unusual sight was seen. The sky was remarkably clear, except for a faint auroral display in the north. But extending in almost a complete belt across the vault of heaven was a narrow bright strip, which attracted much attention because of its very regular shape.

The writer's attention was called to it just after 9.30 p. m. It was seen as a belt of very uniform width, about 10 degrees, near but not exactly on the line of the ecliptic. The edges were quite sharp, especially the northern edge which ran exactly through the planet Jupiter and the star Gemma Coronis. It seemed to be cut off at both ends about 20 degrees above the horizon east and west. Its colour was white or grey with a very faint greenish tinge. It showed little change in intensity or configuration until about 10.45 p. m., when it slowly faded out.

As to its nature, two explanations seem possible.

In favour of its being an exceptional display of the Aurora there is its colour. But against this we have its unusual position—equatorial rather than circumpolar—and its constancy and uniformity. Besides, there was an aurora of the usual form visible at the same time in the north.

A second hypothesis, that it was an unusual form of the Zodiacal Light, may seem at first very unlikely; for practically all observers describe it as a faint wedge, rarely extending far above the eastern or western horizon. When it does span the sky it is brightest at the point directly opposite the Sun—the so-called Gegenschein.

But we must consider its position, its sharp definition and the absence of flashing change as at least suggesting that what we saw was something material, to accept the usual explanation of Zodiacal Light. Moreover, there is at least one record, viz., that of George Jones, U. S. N., at Quito in 1853, of the Zodiacal Light as extending in an unbroken narrow belt across the sky.

A QUANTITATIVE STUDY OF EPITHELIAL NUCLEI OF THE BODY OF THE UTERUS IN CARCINOMA AND IN NON-MALIGNANT HYPERPLASIA.[1]

DONALD MAINLAND,

Dept. of Anatomy, Dalhousie Univ., and the Pathological Institute, Halifax, N. S.

(Received November 15, 1932.)

ABSTRACT.

From fifty specimens of human endometrium (formalin-fixed paraffin sections), images of epithelial nuclei were projected (X 1520 diameters), traced and measured. Thickness (from fine adjustment readings) and volume (from the ellipsoid formula) had great observational errors and were replaced by length and breadth. Both these, especially breadth, closely represented volume. Slide thickness did not appreciably influence measurements. Fifty nuclei sufficiently represented a section, since observational errors accounted for the differences between two sets of fifty nuclei from the same section. The main conclusions were:

(a) The average nuclear size was greater in a series of carcinoma specimens than in a series of hyperplasia specimens, when the technique of preparation was the same; (b) The sizes varied more from specimen to specimen in hyperplasia than in carcinoma; (c) The sizes varied more within the specimen in carcinoma than in hyperplasia; (d) Moderate differences in technique (length of time in fixative, method of dehydration and clearing, etc.) appeared to influence nuclear size.

Although these results are concerned with averages, they can be applied to help in the diagnosis of individual specimens, and would be more valuable for that purpose if technique were more standardized.

Shape (ratio of mean breadth to mean length) varied so much from specimen to specimen that neither disease nor technique had any appreciable effect.

Frequency graphs suggested a slightly greater tendency in carcinoma and in hyperplasia towards extremely large rather than very small nuclei.

A simple colorimetric scale was used to classify staining intensity, numerical equivalents being obtained by diluted water colors. No association was detected between staining and disease or technique; but with standardized staining the method would probably have value, because in individual specimens average staining intensity varied directly with thickness and inversely with breadth.

It is argued that differences between carcinoma and hyperplasia nuclei after preparation represent original size differences, and probably indicate metabolic and physico-chemical differences.

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[1] A preliminary note on this work was given at the 48th annual session of the American Association of Anatomists, March, 1932 (Anat. Record **52,** no. 1 suppl., p. 67).

INTRODUCTION.

Histology, like other departments of biology, is becoming more and more a quantitative science, and one sign of this is the interest taken in nuclear size. This interest is, however, largely centered on nuclear size as a factor in the nucleoplasmic ratio, and on average nuclear sizes, rather than on the variations exhibited by the different nuclei in the same tissue. In biology the variation is as important as the mean, and, moreover, when the variation is taken into consideration, differences between means may be accountable for by chance. For the application to pathology, also, the nucleoplasmic ratio is frequently not available, for when tissues are prepared by simple methods for diagnosis the cell outlines are often lost.

The object of the present investigations was to study the sizes (including size variations) of the nuclei of the mucosal epithelium of the body of the human uterus, and especially to show what size differences exist between the nuclei in carcinoma and in non-malignant hyperplasia. The tests were carried out in such a way as to show whether they might be used to help in the diagnosis from material prepared by routine methods. The cells in the various specimens were looked upon as individuals in a population, and the nuclear measurements were taken without reference to the size of the cells, as are, sometimes, the cephalic measurements of human individuals, without reference to other dimensions. From the outset it had to be remembered that the measurements were made on the end-products of a series of processes—the processes involved in the fixation, imbedding, staining and mounting of the nuclei. The question to be answered was: When the epithelial nuclei of carcinoma and hyperplasia are subjected to the same processes of preparation, how, in regard to size, do the end products differ from or resemble each other? It will be seen from these introductory remarks that the investigations have been carried out along different lines and with different objects from the recent work of O'Leary[2] who was concerned with changes in the nucleoplasmic ratio in association with the menstrual cycle. To O'Leary's paper the reader may be referred for some account of the previous very scanty quantitative work on the histology of the uterine epithelium.

MATERIAL.

Fifty specimens, some being sections, the others endometrial scrapings, were investigated, usually one slide from each specimen. The sources were as follows:

From the Pathological Institute, Halifax, N. S.: 21 specimens;
From the Winnipeg General Hospital: 26 specimens;
From the teaching collection of the Department of Obstetrics and Gynecology, Dalhousie University: 3 specimens.

Since it will subsequently be shown that technique influences the nuclear sizes, details regarding it are desirable. Exact information was not available regarding the method of preparation of the specimens in the third group, and therefore the conclusions had chiefly to be based on the first two. The technique in these two groups was as follows:

> At the Pathological Institute, Halifax: 4 per cent formaldehyde, 1 hour if warmed to 56°C., overnight if cold; water, 2 hours; 50 per cent alcohol, 6 hours; 90 per cent alcohol, 12 hours; acetone, 1 hour; chloroform, 1 hour; paraffin at 53-55° C., 1 hour.
>
> At Winnipeg General Hospital: 4 per cent formaldehyde, 6-8 hours, cold; 70 per cent alcohol, 11 hours; absolute alcohol, 3 hours; xylol, 2 hours; paraffin at 56-58°C., 1½-2 hours.

The staining in both groups was hematoxylin and eosin. The respective techniques had been used uniformly during the period in which the specimens were collected. Moreover, the technique would be more likely to differ slightly from year to year than from month to month, and there was no evidence to suggest that the size differences could be ascribed to such differences in technique, even over long periods of time.

---

[2] O'Leary, J. L. *Anat. Record.* 50, 33, (1931).

METHOD.

General Principles.

A word or two may not be out of place concerning the assumptions underlying the tests[3] applied to prove or disprove the significance of the numerical results. From among the carcinoma specimens in a collection, a number are selected at random, and from each specimen a number of nuclei are measured. The mean or average size (say volume) of these nuclei is determined for each specimen. The average of these averages is found and is compared with the average of similarly determined sizes from specimens of hyperplasia. So that the results may be compared, it is assumed that the means belong to "normal frequency" curves[4]. This is justified because it is comparatively rare to find phenomena (especially

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[3] These tests are called statistical, and it is frequently felt that conclusions established with their aid are, as it were, forced. On the contrary, the tests much more frequently throw doubt on the significance of results that the worker might have been willing to accept as fairly conclusive. In all cases the tests enable one to determine the odds that can reasonably be placed on the significance of results, or, in other words, to estimate the number of times one might meet similar results if chance alone were in operation, instead of the factor or agent that the investigator is postulating.

Even those who criticize the rigid methods of statistics and the assumptions, involved, must, in analyzing data, make assumptions based on analogy, previous experience, and so on. The statistical assumptions are merely more explicit and probably more consistent.

[4] An introduction to the idea of the normal frequency curve and to statistical methods in general is well given by the Eldertons (Elderton W. P. and Ethel M., Primer on Statistics, A. and C. Black, London, 1927). The textbooks that are most informative regarding the application of mathematical methods in the testing of results in biological research are those of Fisher[5] and Tippett (Tippett, L. H. C. The Methods of Statistics, Williams and Nazate, London, 1931).

In this paper prolonged discussion would be out of place. The following definitions and notes may, however, be of use. The standard deviation is the commonest expression of the variation in a series of observations. It is

$$\pm\sqrt{\frac{\text{sum of squares of differences between individuals and mean}}{\text{number of individual observations}}}$$

The coefficient of variation is the standard deviation expressed as a percentage of the mean.

The standard error is an expression for the variation to which the mean is liable if, say, more similar samples are taken. It is

$$\pm\frac{\text{standard deviation}}{\sqrt{\text{no. of observations}}}$$

The standard error is now replacing the probable error (i. e., about 2/3 the standard error), as being more directly calculable.

biological phenomena such as size) in which the means of various groups do not tend to be arranged normally (Fisher[5], p. 99). Even if they are not quite normal, the extent of the error thus introduced is seldom great.

In the present investigations some of the groups contain few individuals (the limitation in the carcinoma groups being imposed by actual scarcity of specimens). The conclusions derived from them are none the less valid provided the tests devised, for example by Fisher[5], for dealing with small numbers are applied.

It should be mentioned that the term "significant" is, in conformity with the usual convention, employed to indicate that the odds are at least 19 to 1 against the value (e. g., a difference between means) being due to chance. Such determinations of odds are in general based on the amount of variation between the individual items that make up the average or other value under consideration.

Detailed Technique.

The images of the nuclei were projected at a linear magnification of 1520 on to pasteboard by a microscope used horizontally (with Zeiss ocular K 10X and Zeiss oil immersion objective 90X, n.a. 1.30). A powerful source of light which can be thoroughly recommended for micro-projection work since it is not subject to the fluctuations of the carbon-arc, was obtained by using the equipment devised by Professor Savage of Winnipeg, to whom the author is indebted for details; viz.: a projection lamp, 5.2 volts, 54 watts, standard base T. 10 C. (Canadian General Electric Co.) used on a circuit of 110 volts a. c., with a resistance of roughly 12 ohms provided by $\frac{3}{4}$-1 lb. of Chromel A resistance wire, no. 14 gauge, the wire being wound on asbestos board[6]. All the apparatus was clamped or screwed in position, including the block of wood against which the pasteboard was held. On this pasteboard, pencil tracings of the epithelial nuclei were made. Nuclei obliquely placed with reference to the plane of the screen were avoided, those only being selected that had their long axes either parallel or perpendicular to the screen of pasteboard. The nuclei were focussed so that their outlines could be traced when at their maximum size. Except where depth measurements, by the fine adjustment of the microscope, were to be taken, it did not, of course, matter if a nucleus was not quite complete, provided only a small slice had been removed in the section-cutting, leaving the region of greatest length and breadth. For the most part, however, the nuclei traced were complete.

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[5] Fisher, R. A. Statistical Methods for Research Workers. Oliver and Boyd, London, 1930.

[6] Care has to be taken to avoid overheating the microscope lenses.

The amount of material examined corresponded to what was sufficient for an ordinary diagnosis. To form a thoroughly representative estimate of nuclear size for each specimen, it was desirable to have all the nuclei scattered at equal distances from their neighbors throughout the section. The nearest practicable approximation to this ideal was obtained by estimating, under low power, the total area to be examined, expressed in terms of the number of microscope fields under the high power oil immersion lens. If there were 500 fields, and 100 nuclei were to be traced, one nucleus was taken from each fifth field as the slide was moved by the mechanical stage[7]. It was found useful, especially when scattered scrapings were to be examined, to outline with ink on the surface of the cover-glass the area to be investigated.

By screw dividers measurements to the nearest 0.1 mm. were made, on the tracing of each nucleus, of the greatest length and of the breadth. (In the taking of the latter measurement, where the curvature was less convex than that of an ellipse the breadth was measured not at the widest part, but so as to approximate to the transverse axis of the corresponding ellipse). In the specimens where nuclear volume was determined, the thickness of the nuclei was found by converting the fine adjustment reading into mm. at the magnification of the tracings of the other dimensions of the nuclei. The volume of the magnified nucleus was obtained by the formula for an ellipsoid: $4/3\ \pi abc$, where a, b, c are the semi-axes. For convenience, the volumes were commonly expressed merely as the product of the three areas, length, breadth and thickness, i. e., the volume of the corresponding rectangular prism.

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[7] It should be pointed out that in specimen No. I, instead of the method described above, eight "oil immersion" fields were taken in different parts of the section so as to be representative of the different types of structure and from each field 25 nuclei were traced.

Influence of Slide-thickness on Measurements Made with a Projection Microscope.

This use of the projection microscope when large numbers of measurements have to be made is becoming more common as a substitute for the employment of the eyepiece micrometer with its attendant eyestrain. It is surprising, therefore, that more attention has not been paid to what is, on theoretical grounds, the most serious disadvantage of the method, namely that if a thicker slide is placed on the stage, the microscope tube must be moved nearer the screen in order to bring the object into focus, and this movement should alter the magnification. In the present series of observations the slide thicknesses varied from 0.686 mm. to 1.487 mm. No correlation was detectable between the slide thickness and the linear dimensions of the nuclei. A more direct test was made as follows. On the thinnest slide available an india ink mark was made covered with transparent mucilage to keep it in place, and then mounted under a coverglass with balsam. Under the conditions of magnification and so on used in the rest of the investigations, two well defined parts of the mark were traced and the distance between them measured. The thickness of the slide was computed from microscope fine adjustment readings on the assumption that the refractive index of the glass and balsam was 1.5. This is a more accurate method than the direct reading of the screw gauge, since the gauge was liable to compress the balsam which held the various glasses together, for, to increase the thickness of the slide, coverglasses were fastened by balsam on to the lower surface of the slide and the tracings and measurements repeated.

The results were as follows:

Slide thickness calculated from fine adjustment readings	Slide thickness from micrometer gauge after tracing	Distance between two points on tracing
mm.	*mm.*	*cm.*
0.6486	0.646	9.215
0.8183	0.931	9.280
0.9588	0.965	9.245
1.1007	1.096	9.285
1.2567	1.238	9.305
1.3989	1.369	9.365
1.5723	1.502	9.225
1.7436	1.667	9.245
1.8621	1.856	9.200
2.0123	1.971	9.260

It will be seen that there is no appreciable influence of slide thickness on the magnification and it is impossible to obtain a correction factor which could be applied to improve the actual readings made on nuclei. Even the variations from the mean that do occur are small (mean distance: 9.2625 mm.; coefficient of variation: 0.5 per cent), compared with the variation from tracing to tracing of the same nucleus on the same slide (see below). Therefore, in projection work of this kind, even extreme variations in slide thickness can be safely neglected, for any effect they produce is obliterated by influence of other agents, e. g., the focussing differences, the personal error, etc. It should be noted that the distance between ocular and screen (about 18 inches) was very great compared with the changes in slide thickness. It is of some interest to contrast with these findings the definite influence of coverglass thickness on magnification when dry lenses are used.[8]

Colorimetric Tests of Nuclear Staining.

A test of nuclear staining intensity was applied as follows: On a piece of card about $\frac{3}{4}$ ins. by $\frac{1}{2}$ ins. was laid a wash of dark violet water color of an intensity like that of the darkest hematoxylin-stained nuclei. This card was labelled A. On another similar piece a somewhat lighter colored wash was laid, and so on, until, on the fifth card, E, the tint was very pale. The five pieces were glued in a row to an index card, so that they could be easily held near each nucleus as the latter was examined. The color intensity was thus recorded without so much liability to subjective error as if it had been classified as "dark", "medium" or "light". The chief drawback to such a method is the presence of tissue near the nucleus under examination, so that white light does not always shine on the scale. There is, however, very often a small clear area somewhere in the field, against which the scale can be held.

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[8] Mainland, Donald. *Anat. Record*, 50, 53, (1931).

RESULTS.

Variation Due to Observational Errors.

Before evaluating the significance of differences between specimens it is necessary to know how much of the variation may be due to observational errors, and in choosing dimensions (volume, length or breadth) of greatest use in such a study, it is desirable, other things being equal, to select the one with least observational error. From one specimen of carcinoma (No. I of Tables 2 and 3) two adjacent nuclei were selected, each was traced thirty times in different parts of the field, and the thickness of each was taken thirty times with different parts of the fine adjustment. Nucleus A was lightly stained and more sharply defined than nucleus B, which was not only darker, but more uniformly stained. The results are shown in Table 1.

To be "significant", a difference must be at least twice its standard error, and therefore some of the apparent differences in this table are not of any account. The most striking points are the great variation of the volumes and the similar variation in thickness measurements. The variation in length and breadth is comparatively small. This difference justifies the subsequent avoidance of thickness measurement, in spite of the desirability of volume determination. The weakness of thickness measurement is partly, perhaps, the fault of the fine adjustment, but probably to a large extent the difficulty in focussing. Where the nucleus is not dense, and its membrane

TABLE 1.

Observational Variations: Thirty Sets of Measurements on Each of Two Nuclei (A and B)

(All dimensions are as magnified)

	Mean	Standard deviation	Coefficient of variation with its standard error - *per cent*	Significance of difference of coefficients of variation.
Length				
A	21.79 mm.	±0.28	1.3±0.17	Difference significant. (standard error: ±0.5).
B	13.44 mm.	±0.47	3.5±0.46	
Breadth				
A	9.87 mm.	±0.37	3.8±0.49	Difference not significant (s. e.: ±0.6).
B	9.94 mm.	±0.27	2.7±0.35	
Thickness				
A	13.68 mm.	±2.52	18.4±2.45	Difference not significant.
B	14.04 mm.	±2.25	16.0±2.13	
Volume				
A	2954 c.mm. (corresponding rect. prism)	±609.4	20.6±2.77	Difference not significant.
	1547 c.mm. (ellipsoid)	±319.1		
B	1875 c.mm. (corresponding rect. prism	±313.2	16.7±2.24	
	982 c.mm. (ellipsoid)	±164.9		

is well defined, the variability of thickness determinations may be no greater than that of breadth.[9]

The breadth variation is in neither nucleus significantly less than that of length; in nucleus B the breadth variation is significantly greater than that of length. The narrow ends of an ellipse would be expected to give more definite points for measurement than the sides, and the variation from one length measurement to another would therefore not be so great. The less well defined nucleus B gives a greater variation in length than does the better defined nucleus A.

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[9] Mainland, Donald. *Trans. Roy. Soc. Can.*, 3rd ser., **25**, sect. V. (1931).

The Number of Nuclei to be Measured in One Specimen.

This question necessarily arises in all such investigations, where it is only practicable to measure a small sample of the available nuclei. The accuracy of a mean of a set of observations in biology increases according to the square root of the number of observations. The mean of $4n$ observations is only twice as accurate as that obtained from n observations. The question of how many readings to take is solved by the physicist by taking a number of the observations and dividing them into two groups. If the two means differ from each other by no more than the step in the measuring instrument, the number is considered sufficient in the circumstances of the experiment (see Campbell[10], pp. 164-5, etc.). In biological investigations it seems possible to extend that method so that measurements can cease when the difference between the means obtained from the two samples is no greater than can be accounted for by the variability of the method itself. In the present instance the preceding section has shown the variability of the method. On the same specimen tests were carried out to determine the necessary number of nuclei. Two hundred nuclei were traced (see footnote to Table 3), and the volumes calculated, the data for each nucleus being on a separate card. The cards were thoroughly mixed by shuffling and one hundred cards picked out at random. From these, again at random, two lots of fifty were taken. The mean volumes (of the corresponding rectangular prisms) were:

Set (1): 1242.38 c.mm.
Set (2): 1184.50 c.mm.
Difference: 57.88 c.mm.

Let the variation be assumed to be the same as that of the test nucleus B (above), i. e., 16.7 per cent or $313.2/1875$, i. e., the variation due to the observations only. The standard deviation of set (1) would then be $\pm(313.2/1875) \times 1242.38 = \pm 207.5$. Therefore the standard error of the mean 1242.38 would be $= \pm 207.5/\sqrt{50}$. Similarly the mean 1184.50 would have a standard error of $\pm 197.8 \sqrt{50}$.

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[10] Campbell, N. R. An Account of the Principles of Measurement and Calculation. Longmans, Green and Co., London, 1928.

The standard error of the difference is—

$$\pm\sqrt{(\text{standard error of set }(1))^2 + (\text{standard error of set }(2))^2}$$

$$= \pm\left(\frac{207.5}{\sqrt{50}}\right)^2 + \left(\frac{197.8}{\sqrt{50}}\right)^2 = \pm 40.5$$

The difference is 57.88, i. e., much less than twice its standard error. Therefore the difference would not be significant even if it were due only to observational errors. The sets of fifty nuclei were thus sufficient to give a representative mean. In some specimens it was not possible to obtain so many nuclei well defined and suitably placed with reference to the plane of the screen. A smaller number was then taken. In each case the number of observations is given in Table 3.

Volumes.

At the outset of the investigations the volumes were calculated for five specimens, as shown in Table 2.

TABLE 2.

Volumes of Nuclei

(All dimensions are as magnified)

Specimen No.	Condition	No. of nuclei	Mean vol. (corresponding rect. prism) *c. mm.*	Standard deviation of vol.	Coefficient of variation of vol. *per cent*	Mean length *mm.*	Mean breadth *mm.*
I	carcinoma	200	1276.93	±683.7	53.5	15.48	9.04
IV	carcinoma	95	1352.2	±587.2	43	13.72	8.84
VII	hyperplasia	118	813.17	±266.8	33	11.77	7.23
III	healthy	99	411.16	±174.9	43	8.77	4.56
II	healthy (premenstrual)	84	724.07	±223.6	31	10.68	6.72

The results suggested that in carcinoma the mean nuclear volume was greater than in hyperplasia, and that in hyperplasia the volume was greater than in the healthy mucosa. It will be noticed that the actual volumes vary from about 700 c. mm. (or 200 cubic microns unmagnified) to about 200 c. mm. (or 60 cubic microns unmagnified). There were not, of course, sufficient specimens prepared by the different techniques to make conclusions from them justifiable, and, rather than pursue farther the volume estimation, it was thought desirable to make use of some criterion of size that would have less observational variation than volume and would be quicker and easier to determine. Such criteria were the length and breadth. In the carcinoma first examined (No. I of Table 3) the coefficient of correlation between length and volume (200 nuclei) was +.49; standard error: ±0.054, while the coefficient of correlation between breadth and volume was +.63; standard error: ±0.043. These coefficients were not only significant themselves, but differed from each other, for the z test (Fisher[5], p. 170) showed that the correlation between breadth and volume was greater than between length and volume. In the main body of the investigation, therefore, breadth and, secondly, length received attention to the exclusion of thickness and volume.

Relationship of Length and Breadth.

The method employed was such that the axis called "length" in some nuclei was not the same as the axis given the same name in others, and it might be thought that the results would depend more on the position of the nuclei than on anything else. It has been shown, however, that breadth and volume are fairly highly correlated, and, to a less extent, length and volume are correlated. The relationship of length to breadth throws further light on this question. In the Winnipeg carcinomata there was a significant correlation between length and breadth (+.6834). This shows that not only is the average length greater than the average breadth in each specimen, as it must be by definition, but, in the series as a whole, the greater the length the greater the breadth. In the four groups: Winnipeg carcinoma, Halifax carcinoma, Winnipeg hyperplasia and Halifax hyperplasia, the correlation between the group mean length and the group mean breadth was very high (+.9938) and significant in spite of the small number of groups (Fisher[5], p. 176). These correlations are explicable by the fact that both mean length and mean breadth are indications of mean volume. In a series of this size or larger, therefore, a very adequate indication of volume can be obtained without actual volume determination.

Comparison of Groups by Linear Measurements.

Table 3 shows the data for this comparison.

Comparison of Mean Breadths:[11]

Winnipeg carcinoma (15 specimens): 9.202 mm.; standard error: ±0.238.

Winnipeg hyperplasia (10 specimens): 8.270 mm.; standard error: ±0.326.

Difference: 0.932 mm.; standard error: ± 0.404.

Since one of the means is based on less than fifteen observations, it is necessary to apply special tests of significance. The t test (Fisher[5], p. 107) is similar in its principle to the standard error test. The t test gives the result in this instance: $t=2.27$; $n=23$, and the tables of t show that the difference must therefore be significant. There are between 20 and 50 chances to 1 against so large a difference being due to chance variations.

Halifax carcinoma (5 specimens): 8.512 mm.; standard error: ±0.341.

Halifax hyperplasia (14 specimens): 6.371 mm.; standard error ±0.191.

Difference: 2.141 mm.; standard error: ±0.391.

The t test showed the high significance of this difference ($t=5.33$; $n=17$; $P<.01$).

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[11] All the sizes are given as magnified. For conversion to the approximate actual size in microns, it is sufficient to take two-thirds of the magnified size in mm. Thus the actual mean breadth for the Winnipeg carcinoma group is approximately 6.1μ.

TABLE 3.

Data on Nuclear Sizes and Staining Intensities
(All sizes are as magnified)

Specimen No.	Staining intensity— no. of nuclei							Breadth			Length			Index:—mean L × 100) ÷ mean Br	Section or scraping	Path. report
	A	B	C	D	E	Un-classified	Total	Mean *mm.*	Stand-ard devia-tion	Coeff't. of variation *per cent*	Mean *mm.*	Stand-ard devia-tion	Coeff't. of variation *per cent*			
Winnipeg carcinoma																
I	—	18	118	61	3	—	200	9.04	±2.24	25	15.48	±4.15	27	58.39	sect.	spher.; sev.
IV	—	2	45	40	7	1	95	8.84	±1.90	22	13.72	±2.63	19	64.43	sect.	spher.; sev.
XVI	—	5	40	43	3	—	91	8.38	±1.39	17	12.36	±1.92	16	67.80	sect.	adeno-; mod
XXII	2	8	21	13	1	—	45	8.37	±1.82	22	13.83	±3.12	23	60.52	sect.	adeno-; mod
XXIII	—	3	34	11	1	—	49	10.38	±2.00	19	14.93	±2.41	16	69.52	sect.	adeno-; mod
XXV	—	1	23	7	—	—	31	10.05	±1.32	13	13.98	±2.29	16	71.89	sect.	adeno-; mod
XXVII	—	1	6	14	4	—	25	9.84	±2.14	22	15.77	±3.47	22	62.40	sect.	adeno-; sev.
XXX	2	17	36	7	—	—	62	9.11	±2.09	23	14.28	±2.86	20	63.79	sect.	adeno-; sev.
XXXI	2	25	17	5	—	—	49	11.66	±2.70	23	17.38	±3.48	20	67.09	scrap.	spher.; sev.
XXXIV	11	21	16	1	—	—	49	8.33	±2.07	25	13.90	±2.51	18	59.93	sect.	spher.; sev.
XXXV	—	14	26	8	1	—	49	9.33	±1.66	18	13.59	±2.23	17	68.65	scrap.	spher.; sev.
XXXVI	—	2	24	8	1	—	35	8.41	±1.64	19	15.34	±2.85	19	54.82	sect.	adeno-; mod
XXXVIII	1	10	29	9	—	—	49	9.27	±1.71	18	13.59	±2.96	22	68.21	sect.	adeno-; sev.
XXXIX	—	—	2	18	29	—	49	8.86	±1.41	16	15.11	±3.08	20	58.64	scrap.	adeno-; sev.
XLVI	5	22	19	3	—	—	49	8.16	±1.47	18	11.54	±2.03	18	70.71	sect.	spher.; sev.
Halifax carcinoma																
V	3	22	42	29	4	—	100	9.49	±2.73	29	15.88	±3.39	21	59.76	sect.	adeno-; sev.
X	11	29	19	5	—	—	64	8.08	±2.11	26	12.95	±3.05	24	62.39	sect.	adeno-; sev.
XII	3	48	42	7	—	—	100	7.50	±1.51	20	11.52	±2.18	19	65.10	scrap.	spher.; sev.
XIV	14	60	23	5	—	—	102	9.31	±3.06	33	14.83	±2.99	20	62.78	scrap.	sev.
XV	—	24	67	7	—	—	98	8.18	±2.29	28	13.08	±3.31	25	62.54	scrap.	adeno-; sev.
Winnipeg Hyperplasia																
XXXVII	6	31	12	1	—	—	50	8.55	±1.45	17	12.86	±2.03	16	66.49	scrap.	sev.
XL	—	5	20	24	1	—	50	8.51	±1.34	16	13.42	±1.82	14	63.41	sect.	sev.
XLI	1	7	29	13	—	—	50	8.43	±2.56	30	14.13	±1.55	11	59.66	scrap.	mod.
XLII*	18	2	—	—	—	—	20	5.58	±1.48	27	10.20	±2.37	23	54.71	scrap.	mod.
XLVII*	—	8	2	—	—	—	10								scrap.	mod.
XLIII	—	21	29	—	—	—	50	9.51	±1.55	16	14.21	±1.93	13	66.92	scrap.	sev.
XLIV	1	12	20	—	—	—	33	8.08	±2.16	27	12.36	±2.63	21	65.37	scrap.	mild
XLIX	—	27	21	2	—	—	50	9.29	±1.67	17	14.00	±2.54	18	66.36	scrap.	mod.
XLV	—	4	22	6	—	—	32	8.21	±1.49	18	13.00	±2.96	23	63.15	scrap.	mod.
XLVIII	1	13	14	4	2	—	34	8.81	±2.23	25	14.41	±2.68	19	61.14	scrap.	mod.
L	2	9	35	8	—	1	55	7.73	±1.69	22	15.87	±1.94	12	48.71	scrap.	mod.
Halifax Hyperplasia																
VI	2	29	49	19	1	2	102	5.67	±1.42	25	11.52	±3.58	31	49.22	scrap.	mod.
VII	1	12	57	42	3	3	118	7.23	±1.49	21	11.77	±2.14	18	61.43	scrap.	sev.
IX	—	2	32	30	5	—	69	6.68	±1.50	22	9.57	±2.57	27	69.80	sect.	mild
XIII	—	10	43	16	1	—	70	5.78	±1.51	26	9.88	±2.33	24	58.50	scrap.	mild
XVII	—	7	26	5	—	—	38	6.00	±1.08	16	9.81	±1.94	20	61.16	scrap.	mod.
XVIII	—	24	37	7	1	—	69	5.31	±1.07	20	8.65	±1.50	17	61.39	scrap.	mild
XIX	1	45	26	6	—	—	78	6.41	±1.51	24	10.37	±2.21	21	61.81	sect.	sev.
XX	—	—	1	18	6	—	25	7.86	±1.08	14	11.72	±1.70	15	67.06	sect.	very mild
XXIV	—	15	48	1	—	—	64	7.09	±1.55	22	12.16	±2.43	20	58.31	scrap.	sev.
XXVI	—	5	25	20	2	—	52	5.69	±1.34	24	9.87	±2.51	25	57.65	sect.	sev.
XXVIII	2	22	23	3	—	—	50	5.88	±0.93	16	8.05	±1.02	13	73.04	scrap.	sev.
XXIX	—	15	54	7	—	2	78	7.04	±1.19	17	10.00	±1.33	13	70.40	scrap.	mild
XXXII	—	3	33	13	—	—	49	6.64	±1.36	21	10.72	±1.70	16	61.94	scrap.	mod.
XXXIII	—	31	17	1	—	—	49	5.92	±1.39	24	11.25	±1.78	16	52.62	scrap.	mod.
Miscellaneous																
XXI	—	18	44	2	—	—	64	7.56	±1.80	24	11.11	±2.07	19	68.05	scrap.	(see p. 91)
III	4	65	26	4	—	—	99	4.56	±1.24	27	8.77	±1.48	17	52.00	sect.	healthy
II	1	15	51	16	1	—	84	6.72	±1.26	19	10.68	±2.12	20	62.92	sect.	healthy
XI	4	31	34	6	—	—	75	8.19	±1.55	19	11.28	±1.97	17	72.61	sect.	premenst. healthy
VIII	1	12	50	30	4	—	97	7.51	±1.76	23	12.20	±2.48	20	61.56	sect.	posmenst. hyperplasia

In the two specimens marked with asterisks (**) relatively few nuclei were suitable for tracing, owing partly to the intensity of staining and to the closeness with which the nuclei were packed together. Both had a rather low mean breadth, and, after careful consideration, in order to avoid bias the two were combined and in all the calculations were treated as one.

All the specimens examined have been included in the table, but the healthy ones were too few for comparison with the others. The last three specimens belonged to the teaching collection and were not accompanied by sufficient data regarding technique.

For the Pathological Reports the author is specially indebted to Doctor MacKeen of the Pathological Institute, Halifax. It will be noted that there is no very close relationship between type or degree of severity and nuclear size.

Abreviations: adeno-, adenocarcinoma; spher., spheroidal celled cancer; mod., moderate; sev., severe.

The mean breadth, therefore, forms a definite criterion of distinction between the carcinoma group and the hyperplasia group in both the Halifax and Winnipeg specimens. By means of a larger number of specimens it would be possible to plot with greater and greater accuracy the limits of the two classes, and to discover the probabilities of an undiagnosed or doubtful specimen lying in one or other of the classes. Considerable interest attached to specimen No. XXI (Halifax). The pathologist's report on this was: "A very profound adenomatous hyperplasia. While not frankly positive for malignancy, I regard the indications sufficiently marked to warrant the case being regarded and treated as such."

The mean breadth is 7.56 mm., and it lies therefore between the hyperplasia and the carcinoma means, but nearer the latter.

Difference between Winnipeg carcinoma and Halifax carcinoma: 0.690 mm.; standard error: ±0.349.

The difference is not quite significant, for it is hardly twice its standard error.

Difference between Winnipeg hyperplasia and Halifax hyperplasia: 1.899 mm.; standard error ±0.378.
The *t* test showed the high significance of this difference.

The importance of similarity of technique cannot be too strongly emphasised where histological measurements are to be made.

These results concerning mean breadths can be summarized as follows: The mean breadth of the nuclei in each of a series of specimens has been obtained, the specimens have been grouped according to disease and technique, and the mean for each group has been determined. When the technique remains the same, the mean nuclear breadth in carcinoma is greater than in hyperplasia. For hyperplasia the mean nuclear breadth is greater in Winnipeg specimens than in Halifax specimens. For carcinoma the Winnipeg mean is again apparently the greater, but the difference is not quite up to theconventional level of significance.

Comparison of Mean Lengths:

Winnipeg carcinoma (15 specimens): 14.320 mm.; standard error: ±0.355.

Winnipeg hyperplasia (10 specimens): 13.446 mm.; standard error: ±0.452.

Difference: 0.874 mm.; standard error: ±0.575.

Halifax carcinoma (5 specimens): 13.652 mm.; standard error: ±0.684.

Halifax hyperplasia (14 specimens): 10.381 mm.; standard error: ±0.311.

Difference: 3.271 mm.; standard error: ±0.751.

Specimen No. XXI, referred to above, had a mean of 11.11 mm. and therefore lay between the Halifax the hyperplasia mean and the Halifax carcinoma mean. In the Halifax specimens the difference between the means was highly significant. In the Winnipeg specimens, although the carcinoma means appeared greater, the variation between the items that formed the means was so great that the difference was not significant.

Difference between Winnipeg carcinoma and Halifax carcinoma: 0.668 mm.; standard error: ±0.771; difference not significant.

Difference between Winnipeg hyperplasia and Halifax hyperplasia: 3.065; standard error: ±0.549.

The t test confirmed the supposition that the mean length in the Winnipeg series of hyperplasia specimens was definitely greater than that in the Halifax series.

The mean lengths, therefore, in no instance disagreed with the conclusions reached by a study of the mean breadths, but length, probably on account of its variability, was apparently not so good a criterion as breadth. In this connection it should be remembered that the breadth is much more closely correlated with volume than is length.

The actual differences, although significant, may not appear great until it is noted that they range from 6 per cent to over 25 per cent, and, if represented as volumes (the cube of the linear measurements), the differences would become much more striking.

Comparison of Variations: Two classes of variation come under consideration: the variation from specimen to specimen and the variation within the specimens. In each of these classes the variation must be considered in two ways: as absolute variation and as variation in proportion to the mean value, about which the variation takes place.

(*a*) *Varitaion from Specimen to Specimen*: The absolute variation is expressed as the standard deviation, and the variation in proportion to the mean is expressed as the coefficient of variation. These values were:

Group	No. of Specimens	*Breadths*		*Lengths*	
		Standard deviation	Coefficient of variation *per cent*	Standard deviation	Coefficient of variation *per cent*
Winnipeg carcinoma	15	0.9202	10.00	1.375	9.60
Winnipeg hyperplasia	10	1.0296	12.45	1.429	10.63
Halifax carcinoma	5	0.7635	8.97	1.530	11.21
Halifax hyperplasia	14	0.7160	11.24	1.174	11.31

Since the number of specimens was small, the *z* test (Fisher[5], p. 195) was applied to determine the significance of the differences between the standard deviations. The conclusions with regard to length and breadth were (1) that there was no difference between the absolute variations from specimen to specimen in the carcinoma groups as compared with the same variations in the hyperplasia groups, and (2) that no significant difference could be ascribed to technique. But, if the actual variation is the same in carcinoma as in hyperplasia, and, as has been shown, the mean breadth is greater in carcinoma, then the variation considered in terms of the mean (i. e., the coefficient of variation) should be greater in hyperplasia.

In regard to both length and breadth this appears, from the data just recorded, to be correct. To prove whether the effects might be due to chance the *t* test was applied in the following manner:

Difference between coefficients of variation (breadth)—
Winnipeg specimens: 2.45; Halifax specimens: 2.27.
Mean of the two differences: 2.360.

t(Fisher[5], p. 105) $= 26.2$; $n = 1$; $.05 > P > .02$. This result shows that the mean difference is significant, and therefore the variation of breadth considered in relation to the mean breadth is greater in carcinoma than in hyperplasia. In the cases of length the differences are not sufficiently alike in Halifax and Winnipeg to justify the conclusion, but this does not detract from the importance of the results derived from breadth. The exact meaning of these results deserves consideration, and a clearer conception of this meaning may be obtained if it is recalled that roughly three times the standard deviation on either side of the mean marks, in the normal frequency curve, the upper and lower limits of the series of observations that form the curve. For a given technique the standard deviation is the same for hyperplasia as for caricnoma, and therefore the upper and lower limits of the series must be as far away from the mean in hyperplasia as in carcinoma, and, relative to the size of the mean, the hyperplasia collections are less uniform than are the corresponding carcinoma collections.

There was no definite association between technique and these coefficients of variation.

(*b*) *Variations within Specimens.* The standard deviations of each specimen are shown in Table 3, and instead of the thorough, but rather complicated method of analysis of variance, the means of these standard deviations were studied. Similarly, the coefficients of variation give for each specimen the variation in proportion to the mean of that specimen, and the means of these coefficients show the relation between variation and mean for an average specimen of the group concerned, say carcinoma.

Group of	No. specimens	Breadths		Lengths	
		Mean of standard deviations	Mean of coefficients of variation *per cent*	Mean of standard deviations	Mean of coefficients of variation *per cent*
Winnipeg carcinoma	15	±1.837	20.00	±2.799	19.53
Winnipeg hyperplasia	10	±1.762	21.50	±2.245	17.00
Halifax carlnoma	5	±2.340	27.20	±2.984	21.80
Halifax hyperplasia	14	±1.316	20.86	±2.053	19.07

Where there was doubt regarding the significance of the differences, the *t* test was applied, and the conclusions regarding absolute variation in breadth were as follows. There was no significant difference in mean standard deviation between Winnipeg carcinoma and Winnipeg hyperplasia. The average Halifax carcinoma, however, varied more within the specimen than did the average Halifax hyperplasia specimen, and more also, than the average Winnipeg carcinoma. The standard deviations of length gave more conclusive information. The average length variation was definitely greater in carcinoma than in hyperplasia, both in the Winnipeg and Halifax groups. Technique had no uniform effect.

When the variation within the specimens was considered in relation to the mean, by use of the coefficient of variation, the breadth variation in the Halifax carcinoma group was again shown to be greater than in the Halifax hyperplasia group. For the lengths the differences in the two groups (Winnipeg and Halifax) were combined, giving a mean difference between carcinoma and hyperplasia of 2.63, the carcinoma being the greater. The *t* test showed that this difference was significant, and therefore it can be concluded that there is greater variation in length in the average carcinoma specimen, even in proportion to its mean length, than in the average hyperplasia. In a similar way it was shown that the average Halifax specimen varied more in itself in regard to length, even in proportion to its mean length, than did the average Winnipeg specimen.

The conclusions to be drawn from sections (*a*) and (*b*) may be summarized by stating that the nuclear size varies more from specimen to specimen in hyperplasia than in carcinoma, but varies more within the specimen in carcinoma. Technique seems to have to have no very definite influence on the variation from specimen to specimen, but the Halifax technique is associated with a greater variation in nuclear length within specimens than is the Winnipeg technique.

(*c*) *Correlation of Breadth and Standard Deviation of Breadth*: The question to which the preceding two sections naturally lead is: Are the greater mean breadths associated with greater variations, and the smaller mean breadths with smaller variations? The coefficients of correlation between mean breadth and standard deviation were:

Winnipeg carcinoma (15 specimens): +.557; significant.
Winnipeg hyperplasia (10 specimens) : +.144; not significant.
Halifax Carcinoma)5 specimens) : +.941; significant.
Halifax hyperplasia (14 specimens) : +.041; not significant.

In both groups of carcinoma there is a definite positive correlation: the variation tends to vary in the same direction as the mean breadth. In hyperplasia a high mean may be associated with either a high or low variation, and the same applies to a low mean.

Shape of Nuclei.

The impression obtained from a preliminary survey of the specimens was that in carcinoma the nuclei tended to be broader ellipsoids than in hyperplasia. In seven specimens the ratio of breadth to length was determined for each nucleus separately. In all the specimens there was calculated an index: (mean nuclear breadth x 100)/(means nuclear length).

The results set down show a mean nuclear length very close correspondence between the results of the two methods. The "mean index" shows, in the form of a percentage, the results of the first method, the "index of means" shows those of the second.

Specimen No.	No. of Nuclei	Mean Index	Index of Means
I (carcinoma)	200	60.8	58.39
II (healthy pre-menstrual)	84	65.0	69.92
III (healthy)	99	53.8	52.00
V (carcinoma)	100	60.4	59.76
VI (hyperplasia)	102	53.9	49.22
VII (hyperplasia)	118	63.3	61.43
IX (hyperplasia)	69	71.7	69.80

The coefficient of correlation between the mean index and the index formed by the means was +.9900, and this, in spite of the smallness of the numbers compared was highly significant. Therefore, one is perfectly justified in substituting the shorter method of estimating average shape for the longer method, whereby the ratio for each nucleus is found.

Table 3 gives for each specimen the index formed by the mean breadth and mean length. The mean values derived from these are:

Winnipeg carcinoma (15 specimens): 64,453 per cent.
Winnipeg hyperplasia (10 specimens): 61.592 percent.
Halifax carcinoma (5 specimens): 62.514 per cent.
Halifax hyperplasia (14 specimens): 61-881 per cent.

The standard error and t tests showed that there was no significant difference attributable to disease or to technique. The average shape of the nuclear image is, therefore, so variable from specimen to specimen, that in the series examined neither disease nor technique had any appreciable effect.

Frequency Distributions.

Graphs were drawn for nearly all the specimens, to show the numbers of nuclei in the different length and breadth classes —frequency distribution graphs. These graphs presented very varying appearances, some being practically symmetrical, some skewed to the left, others to the right. It was thought that in specimens where the variation from the mean was great this variation might be accounted for by the presence, along with adult cells, of a fair number of young cells, with small nuclei; but the graphs showed that it was not possible to account for the differences in variation in any one way. Composite graphs were constructed, to eliminate minor peculiarities due probably to insufficiency of the numbers of observations in individual specimens. Two of these graphs are shown in Fig. I.

For comparison, the various specimens of carcinoma (Winnipeg and Halifax) have been supposed to contribute equally to the total 100 nuclei, and each of the hyperplasia specimens (Winnipeg and Halifax) has been supposed to contribute equally to the total 100 hyperplasia nuclei. The graph, therefore, is a composite frequency distribution graph of breadths arranged on a percentage basis. It shows that the mode (region of greatest frequency) is greater in carcinoma (8.1-10 mm.) than in hyperplasia (6.1-8 mm.). Each curve is fairly symmetrical, but there is a tendency for a more gradual slope down to the right than to the left. This was seen also in graphs made from Winnipeg and Halifax specimens separately, and, although no statistical tests were applied, it appears probable that the feature has some significance, as indicating a greater tendency for the occurrence of extremely large nuclei than for the occurrence of extremely small ones.

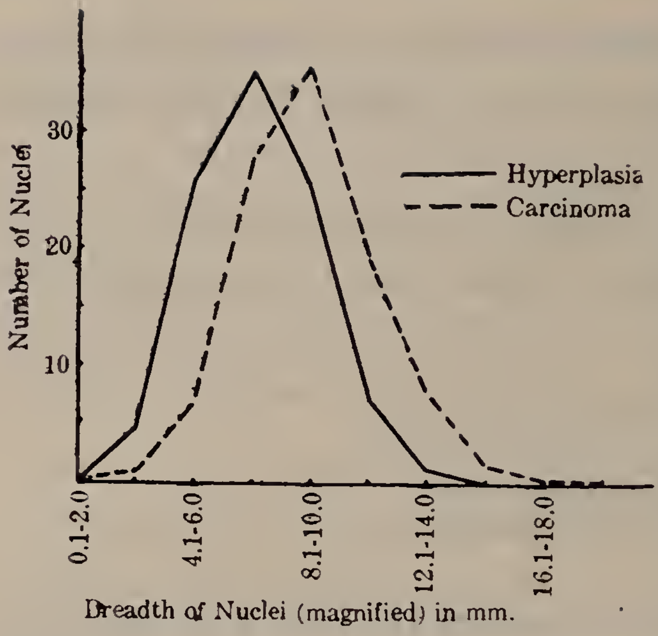

Fig. 1. Frequency Distribution Graphs of Nuclear Breadth. Each is a percentage graph, and is composite—hyperplasia 22 specimens; carcinoma 20 specimens.

Staining Intensity.

Colorimetric study of ordinary histological material has not been developed to any extent, and yet crude quantitative judgments are frequently heard, wherein it is stated that one specimen or disease shows more darkly stained nuclei than another. The records given here show how little trust may be placed on such statements. It has been mentioned in the section on methods that the nuclei were classified according to a scale of purple tints, varying from A (very dark) to E (very light). Table 3 shows that the specimens varied much from each other in the proportions of nuclei found in the different classes, and tests were applied to ascertain whether these differences were associated with differences in technique or disease.

In the first place the specimens were compared by the χ^2 test (Fisher[5], p. 75) according to the intensity (A, B, C, etc.)

of the chief number of their nuclei. There was no significant difference between the different groups, either in association with disease or technique.

A second test was made by calculating for each specimen the percentage of the total nuclei classified as dark (classes A, B and C)—

	Mean percentage of dark nuclei	Standard error
Winnipeg carcinoma (15 specimens):	68.61	±6.4
Winnipeg hyperplasia (10 specimens):	86.68	±4.8
Halifax carcinoma (5 specimens):	88.04	±4.7
Halifax hyperplasia (14 specimens):	74.99	±6.8

It appears as if in the one group the hyperplasia specimens and in the other the carcinoma specimens had the preponderance of darkly stained nuclei. There was no significance as high as the conventional level of 19 to 1 in any of the differences. The nearest to such was the difference between Winnipeg carcinoma and Winnipeg hyperplasia ($t = 1.91$; $n = 23$; $P < .1 > .05$, but nearer the latter).

It is true that the scheme devised for the test was somewhat crude, but if so crude a test indicates nothing it is questionable if one that was finer would show any more significant difference. The variation from specimen to specimen is so great that it obliterates differences attributable to disease if such exist. The conclusion is that, as routine staining is at present conducted, it cannot form a useful basis for a colorimetric comparison of tissues. The question that therefore arises is whether it is worth while to standardize staining methods in respect of strength of solution, duration, dehydration and mounting. (Probably, of course, the section thickness would have to be standardized). Investigations of individual specimens have indicated that such standardization might well be productive.

To ascertain whether there was in any one specimen an association between size of nucleus and staining intensity, it was desirable to express this intensity numerically instead of by letters. In order to do this, a dark mixture was made of water and the water-color paint that had been used to make the colorimetric scale. The mixture was placed in a test tube in front of a white paper and compared with the colors on the scale. The mixture was diluted until it matched color A. Then it was further diluted, to a known degree, until it matched color B. This process was continued until the faintest color (E) was matched. The experiment was carried out three times, and the following figures were derived:

E = 1
D = 1.3
C = 2.5
B = 4.7
A = 11.3

Although there was a good deal of variation between the three experiments, it was considered that these figures expressed, as closely as so simple a test could do, the relative intensities, and it was certainly a more accurate method than the method of "ranking", whereby the numbers 1, 2, 3, 4, 5 would replace the letters—a method commonly employed where more exact numerical equivalents cannot be obtained (Tippett[12], p. 168). With the values obtained, the following correlations were calculated for specimen No. I (Winnipeg carcinoma; 200 nuclei).

Coefficient of correlation between breadth and staining: —.277; standard error ±0.065.
Coefficient of correlation between thickness and staining: +.352; standard error ±0.062.
Coefficient of correlation between breadth and thickness: —.013; standard error ±0.071.

To be significant, a coefficient of correlation must be at least twice its standard error, and these results therefore indicate that, where the breadth of the nucleus is greater, the staining intensity tends to be less. The possible range of the coefficient is from +1 (perfect positive correlation) through 0 (no correlation) to —1 (perfect negative correlation), and therefore the association here is not very great, but it is none the less definite. Secondly, where the thickness is greater, the staining intensity tends to be greater. The thicker the nucleus, the greater will be the impediment to the rays passing through it, provided its composition is similar in both cases. It might be thought that the inverse relationship between the staining and breadth could be explained if a greater breadth were associated with a less thickness. There was, however, as shown above, no significant correlation between breadth and thickness, and therefore the breadth-staining relationship must be explained independently. The broader the nucleus, the more widely spread out is its staining material, and therefore the paler does it appear.

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[12] Tippett, L. H. C. The Methods of Statistics. Williams and Norgate, London, 1931.

Although similar correlation tests were not applied throughout the series, other observations showed that this correlation existed. For each specimen the mean breadth and mean length of the nuclei were calculated for the different classes A, B. C, D and E. Examples are:

	A	B	C	D	E
Specimen No. I					
Mean breadth	—	7.4	8.9	9.9	9.2
Mean length	—	11.2	15.3	17.2	15.1
Specimen No. XXVIII					
Mean breadth	4.9	5.8	6.0	6.8	—
Mean length	7.7	7.8	8.2	9.1	—

In all except a few instances there was an increase in the mean breadth and mean length at each step from the darker nuclei to the lighter. The staining, therefore, is partly a function of size, and this suggests that there is a similar amount of basiphil chromatin in all the nuclei of a given specimen. The larger the nucleus, the less the amount of stained material in the given volume, and the less the intensity of staining. It has been shown above that nuclear size is associated with disease, and, now, that, for any given specimen, nuclear staining is associated with size. It appears therefore that staining intensity could be shown to be associated with disease if the staining technique were uniform for all the various specimens.

Discussion.

The smallness of the number of specimens used in these investigations may give rise to doubt regarding the validity of the conclusions, and therefore it is desirable to note the principles upon which the conclusions are based. Each set of specimens (carcinoma and hyperplasia) has been divided into two groups according to technique (Winnipeg and Halifax). Where the Halifax specimens corroborate the Winnipeg specimens regarding differences associated with disease, and the differences are proved significant by the finest statistical tests, confidence in the results is felt to be justified; and similarly where carcinoma specimens corroborate hyperplasia specimens regarding differences associated with technique.

Four main size differences between carcinoma and hyperplasia nuclei have emerged—the greater average size in groups of carcinoma specimens; the greater variation within carcinoma specimens; the greater variation from specimen to specimen in hyperplasia; and the positive correlation between size and variation in carcinoma, in contrast to the lack of correlation in hyperplasia. Before these results can be finally interpreted, a large amount of experimental work must be carried out, but the possible lines of the interpretation can already be indicated. That differences of some kind, morphological or physico-chemical, between the two groups of nuclei have been disclosed will surely be admitted even by those who are most ready to explain histological findings as artifacts.

It must first be asked whether the size differences denote an original size difference between carcinoma and hyperplasia nuclei, or whether these nuclei may have started with the same average size and size range, and then, under the influence of the fixation and other processes, become differentiated. Little of detail is established regarding the influence of such treatment on nuclear size (cf. Tarkhan[13]), but it seems reasonable to suppose that, where shrinkage occurs owing to dehydration, clearing and imbedding, the amount of shrinkage will be proportional, more or less, to the original bulk of the nucleus, the larger losing more than the smaller. If, in a collection of nuclei, say one fifth of their volume were taken off each, i. e., from those of average size, the smallest and the largest, then the absolute size range would lessen, but the proportion of the range to the mean would not alter, i. e., the coefficient of variation would remain the same as before. Now the mean of a series of hyperplasia specimens is less than the corresponding carcinoma mean, and yet the standard deviation (and therefore the absolute range of variation) is the same in hyperplasia as in carcinoma, and the coefficient of variation is correspondingly greater in hyperplasia. It seems therefore very unlikely that the hyperplasia has merely been diminished from the carcinoma size in the preservation processes. It seems much more reasonable to suppose that the size differences in the fixed specimens represent, to some extent at least, original size differences.

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[13] Tarkhan, A. A. *J. Royal Microsop. Soc.*, **51**,387 (1931).

The next question that might be asked is whether the size differences represent a difference in the amount of primary nuclear material, say chromatin, or whether they indicate a difference of activity and a corresponding difference of the physico-chemical state of the nucleus (which would also probably give a differential response to technique). It is true that the results suggest that a series of hyperplasia specimens might, as regards nuclear size, be converted into a series of carcinoma specimens by adding a constant amount of nuclear material to each nucleus. The mean size would be increased, the absolute range would remain the same, and the coefficient of variation would therefore be less, just as in the actual carcinoma series. It appears much safer, however, to suppose that the metabolic activity could, if sufficiently known, account for the phenomena. If this view is adopted and applied to the interpretation of the other facts noted, it can be stated that the hyperplasia specimens differ from each other more widely than the carcinoma specimens in the average activity or physico-chemical state of their nuclei, and also differ widely from each other in the range of these phenomena found in the same specimen; but that on the average, carcinoma nuclei, within the small area of an ordinary section, differ more from each other than do hyperplasia nuclei.

It appears, therefore, as if, by study of more specimens, and of individual alveoli and cell clumps, light may be thrown on the intimate structure and activity of tissues, but at the same time the possibility of the application of the method to differential diagnosis should not be overlooked. Routine quantitative methods in pathology are now largely confined to fluids and to cells (especially blood cells) suspended in fluid. There is already a chemical pathology, but there seems no reason why there should not be a "physical pathology", concerned with the measurement of solid tissues in section.[14] If this were shown to be a useful technique, the labor of the measurements could be rendered very small, especially by electrical devices connected with the screw dividers. All that would be necessary beyond this would be the standardization of the technique of fixation, imbedding, staining, etc. The present results have shown, for instance, that the Halifax technique is associated, for some reason or other, with greater variation in nuclear length within the specimen than is the Winnipeg technique. There is a strong suggestion that nuclear sizes are larger with the Winnipeg technique, and it seems, also, as if the Halifax method gives a greater difference between carcinoma nuclear sizes and those of hyperplasia, but this may well be due to differences in the specimens rather than in the techniques. The two methods differ from each other in various respects, and it would be necessary to isolate these differences experimentally and to standardize the technique which best brought out measurable differences. It is true that the diagnostic value of the method has not yet been proved and there is much overlapping of the two series, carcinoma, and hyperplasia, when arranged according to size, as may be seen by comparing the various sections of Table 3, but this overlapping is probably in part due to small differences in technique from specimen to specimen, and the part so caused would be eliminated by standardization of technique.

[14] The possibilities of this kind of test are shown in the pioneer work of Savage, (Savage, A., Williams, W., and Fowler, N. M., *Trans. Roy. Soc. Can.* 3rd Ser. **21**, Sect. v, 425 (1927), *Can. J. Research* **3**, 327 (1930)) and his collaborators, who have shown that low fertility of bulls and horses is indicated by a high coefficient of variability of the head length of their spermatozoa.

It might be that in this particular problem no sufficiently fine differentiation could ever be reached, but, whatever may be the final outcome of work along these lines, there is little doubt that there exists in such quantitative procedures a method which, because of its simplicity, can be used in differential diagnosis, and, because of its objective accuracy, can be used to disclose the details of structure and metabolism of tissues.

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THE ODONATA OF THE MARITIME PROVINCES.

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Very little has been published on the Odonata of the maritime provinces of Canada[1]. Two short local lists[3, 8b] and a number of scattered records in other papers[2-8c] include all that has been hitherto known of their distribution in this region.

Since the writer has gathered a considerable number of records from various sources, which together are sufficient to

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[1] Nova Scotia, New Brunswick and Prince Edward Island.

[2] Calvert, Philip P. Notes on some North American Odonata, with descriptions of three new species. *Trans. Amer. Ent. Soc.*, **17**, 23-40 (1890).

[3] Calvert, P. P., and Sheraton, Wm. Notes on Nova Scotian Dragonflies. *Can. Ent.*, **26**, 317-320 (1894).

[4a] Fletcher, Jas. and Gibson, A. Entomological Record for 1907. 38*th Ann. Rep. Ent. Soc. Ont. Odonata*, 131-132 (1908). [4b] Entomological Record for 1908. 39*th Ann. Rep. Ent. Soc. Ont. Odonata*, 114-115 (1909).

[5a] Gibson, A. Entomological Record for 1914. 45th *Ann. Rep. Ent. Soc. Ont. Odonata*, 45 (1915). [5b] Entomological Record for 1917. 48th *Ann. Rep. Ent. Soc. Ont. Odonata*, 25-27 (1918).

[6a] Hagen, H. A. Synopsis of the Neuroptera of North America. *Smiths. Misc. Coll.* 14, xvii + 347, (1861). [6b] Synopsis of the Odonata of North America. *Proc. Bost. Soc. Nat. Hist.*, **18**, 20-96 (1875). [6c] Synopsis of the Odonate Genus Leucorhinia. *Trans. Amer. Ent. Soc.*, **17**, 229-236 (1890).

aSelys-Longchamps, Edmond de, Synopsis de Gomphines. *Bull. Acad. Roy. Belg.*, **21**, (2), 23-112 (1854). [7b] Synopsis des Agrionines. *Bull. Acad. Roy. Belg.*, (2) **13**, 286-359 (1862). [7c] Synopsis des Cordulines *Bull. Acad. Roy. Belg.*, (2) **31**, 228-355 (1871). [7d] Quatrième Addition au Synopsis des Gomphines. *Bull. Acad. Roy. Belg.*, (2) **46**, 658-698 (1878).

[8a] Walker, E. M. The North American Dragonflies of the Genus Aeshna. *Univ. Toronto Studies, Biol. Ser.* No. 11, 1-213 (1912). [8b] Some dragonflies from Prince Edward Island. *Can. Ent.*, **49**, 117-119 (1917). [8c] The North American Dragonflies of the Genus Somatochlora. *Univ. Toronto Studies, Biol. Ser.* No. 26, 1-202 (1925).

Proc. N. S. Inst. Sci., xviii, pt. 3.

give a general idea of the odonate fauna of the Maritimes, it was decided to bring these together in the form of a preliminary list. This list probably includes somewhat less than seventy-five per cent of the total number of species to be expected from the region under consideration. Some of the listed species, which are undoubtedly of general distribution, are still known from not more than one province and in one or two localities only; thus, taken by provinces, the lists are very incomplete. Nearly all the species recorded, however, are to be expected in all three provinces. Two species that do not appear in the list, viz., *Somatochlora williamsoni* Walk. and *S. albicincta* (Burm.) were taken by the writer at a bog lake near Lake Temiscouata, Que., about 25 miles from the New Brunswick boundary line; and two others, *Aeschna sitchensis* Hag.[9] and *A. juncea* L.[10] have been recorded from the Magdalen Islands, which, though belonging to Quebec, are actually nearer Prince Edward Island and Cape Breton Island, N. S., than any part of Quebec.

In the present paper an attempt has been made to include all previous records together with new data based chiefly on the collections which are listed below under the names of the localities and collectors. The abbreviations for the latter, used in the list of species, are given in brackets.

NOVA SCOTIA.

1. Digby, Annapolis (Granville, etc.), Kings (Kentville, Wolfville), and Colchester Counties (Truro): H. G. Payne (H. G. P.); a few also by J. Russell and M. D. Payne.

2. Annapolis and Nictaux Rivers, near Middleton, and Lawrencetown, Annapolis Co., and Little River, St. Mary's Bay, Digby Co.: Dr. A. G. Huntsman (A. G. H.).

3. Shubenacadie River (Elmsdale, Milford Station), Hants Co.: Dr. A. H. Leim (A. H. L.).

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[9] *Ent. Rec.* '17, p. 26 [10] Williamson, *Ent. News*, 13, 146, (1902).

4. Eastern Harbour, Neil's Harbour, Aspy Bay and the vicinity of Grand Étang, Cape Breton Island: A. G. Huntsman.

5. Pictou, E. M. Walker (W).

NEW BRUNSWICK.

1. Scotch Lake, Carlton Co.: W. H. Moore (W. H. M.).

2. Youghall: A. Gibson.

3. St. Andrews and vicinity (Chamcook Lake, Bocabec Lake, Gibson Lake, etc.): A. G. Huntsman (1916-1919), E. M. Walker (1923), W. S. Hall (W. S. H.) (1927), and E. S. Pentland (E. S. P.) (1932).

4. Fredericton and vicinity; St. John; Kings Co., between Sussex and Petitcodiak; St. Margarets and other localities between Shediak (Kent Co.) and Bathurst (Gloucester Co.): E. M. Walker, assisted by Messrs. F. P. Ide and E. H. Walker.

The writer is particularly indebted to Dr. Huntsman and Dr. Leim for their kind donation of all the material which they collected. His thanks are likewise due to Messrs. Gibson, Pentland and Hall for the donation of specimens, to Mr. A. D. Pickett, Provincial Entomologist for Nova Scotia, for the loan of material in the collection of the Provincial Department of Agriculture, Truro, and to Mr. H. G. Payne for the loan of many specimens.

The Odonata of the maritime provinces consist mainly of species of the Canadian zone but include some that are more typical of the Alleghanian, three (*Calopteryx amata*, *Enallagma minusculum* and *Ophiogomphus aspersus*) that are not known to occur as far west as Ontario, and one (*Pantala hymenea*), which is definitely austral but occasionally wanders northward into the Transition zone. St. Andrews, N. B., where more thorough collecting has been done than elsewhere, is situated in the extreme southwestern part of the province but, on the whole, has a decidedly boreal fauna, including such species as *Somatochlora franklini*, *forcipata* and *cingulata*, and *Leucorrhinia hudsonica*. Nevertheless, there is an admixture of such Alleghanian species as *En-*

allagma vesperum, *E. exsulans*, *Argia moesta putrida*, *Aeschna verticalis*, and *Libellula lydia*, together with the distinctly austral *Pantala hymenea*. Doubtless, when the odonate fauna of the Annapolis Valley is better known, it will be found to contain an austral element.

As indicated above, collecting was done by the writer chiefly in 1923 and 1932. In 1923 nearly a month was spent at the Atlantic Biological Station, near St. Andrews, N. B., and much time was given to the collecting and rearing of Odonata. In 1932 Messrs. F. P. Ide, E. H. Walker and the writer motored from Toronto to Rivière du Loup, Que., thence southward through New Brunswick to St. John and eastward to Pictou, N. S., returning through New Brunswick by the coastal route. Collecting was done in the vicinity of Fredericton, St. John, near Petitcodiak, N. B., and Pictou, N. S., and short stops were made at a few other points, chiefly along the outer coast between Shediak and Bathurst.

Some of the stations where collections were made will be briefly described as examples of the more definite or distinctive types of odonate habitats.

VICINITY OF ST. ANDREWS, N. B.

In this locality there is no river collecting but there are several fine lakes and some bog-ponds and small, spring-fed brooks. It is a good locality for Somatochloras but a poor one for gomphines. The late season forms have not been properly collected. The brooks were devoid of Calopteryx in 1932 but were inhabited by *Cordulegaster diastatops* and *Aeschna umbrosa*. Somatochloras were abundant, especially *S. forcipata*, *kennedyi* and *walshii*, which are bog or bog-stream species. Under these circumstances it was somewhat surprising that the commonest *Leucorrhinia* was *intacta* instead of *proxima*, although the latter was the more abundant at Bocabec Lake.

Of the several lakes in the vicinity of St. Andrews two only were visited by the writer, viz., Chamcook Lake and Bocabec Lake.

Chamcook Lake is the source of the water supply of St. Andrews and is a clear lake of considerable depth, with rocky and pebbly shores, interesting on account of the land-locked salmon (*Salmo sebago*) and smelt which it contains. Several small ponds, once part of the lake, have been cut off by the railway embankment which follows the south-east shore. Among the dragonflies breeding in the lake itself are *Argia moesta putrida, Basiaeschna janata, Gomphus exilis* and *Didymops transversa,* while about the largest of the ponds both Argias occurred, together with *Lestes rectangularis, Ischnura verticalis, Enallagma ebrium, Basiaeschna janata, Tetragoneuria c. simulans* and *Libellula quadrimaculata.* This pond is about 75 yards long, but only a few yards wide. It is very shallow at one end, where the bottom is covered by slippery, angular stones, but is much deeper at the other. It was only at the shallow end, where there was a little boggy patch, that *L. quadrimaculata* flew. *Argia moesta putrida* was probably only a wanderer from the lake. The pond in 1923 was fairly free of vegetation and represented a somewhat early ecological stage.

Bocabec Lake is a shallow body of clear water, less than a mile long and perhaps a fourth as wide, with a short outlet into Passamaquoddy Bay. We examined only the upper end, where it is very shallow and marshy and grown over with a considerable belt of emergent vegetation, chiefly *Equisetum fluviatile.* Dragonflies were very abundant here, the following species having been observed in the two hours or so spent at this station: *Lestes disjunctus, Nehalennia irene, Enallagma boreale, E. minusculum, E. civile, Aeschna canadensis, Gomphus exilis, Cordulia shurtleffi, Dorocordulia libera, Somatochlora cingulata, Tetragoneuria c. simulans, Didymops transversa, Libellula quadrimaculata, Sympetrum decisum, S. danae, Leucorrhinia intacta* and *L. proxima.*

VICINITY OF FREDERICTON, N. B.

Collecting was done at a number of stations in the environs of Fredericton but mention will be made of the following only:

(1) A small narrow pond, about two miles south of the city, occupying a depression between the highway and railway embankment and exposed to full sunlight. It was weedy and ecologically mature. On July 9, 1932, it swarmed with dragonflies of the following species: *Lestes uncatus*, *L. forcipatus*, *Nehalennia irene*, *Ischnura verticalis*, *Enallagma hageni*, *Agrion resolutum*. *Libellula quadrimaculata*, *Sympetrum decisum* *Leucorrhinia intacta* and *L. hudsonica*.

(2) French Lake, an expansion of Rockwell Stream occupying a wide depression and surrounded by an extensive open marsh, visited July 10, 1932. The weather was fine but a strong northwest wind had almost cleared the marsh of dragonflies, except *Enallagma hageni* and *Ischnura verticalis*, which found shelter in the sedge, and tenerals of *Sympetrum decisum*, which were emerging from puddles in the marsh. In the lee of a fringe of willows, which formed a scattered zone between the open marsh and the woods, hundreds of dragonflies were sheltered. These were nearly all older individuals of *S. decisum*, but *Dorocordulia lepida* was taken, including a pair in copula, *Leucorrhinia intacta* and *Libellula quadrimaculata*. Other species occurred along the margins of woods nearby, e. g., *Tetragoneuria spinigera*, *T. c. simulans*, and *Somatochlora kennedyi*.

(3) Rockwell Stream, a tributary of the Oromocto River. We collected over a section of the stream a few miles above French Lake, where it pursues a fairly rapid course over a pebbly or stony bottom between wooded banks a few feet high. The water here is peat-stained and not very cold. The principal dragonflies taken were the three species of *Calopteryx*, *Enallagma exsulans*, *Basiaeschna janata*, *Ophiogomphus carolus*, *Gomphus brevis*, *Cordulegaster maculatus* and *Helocordulia uhleri*. *Calopteryx amata* was relatively scarce, the other two species abundant.

CARDWELL TOWNSHIP, KINGS COUNTY.

On July 12, 1932 we collected for an hour or so on a clear cold stream, a branch of the Kennebecasis River, which crosses the highway between Sussex and Petitcodiak. This part of the stream is somewhat smaller than the Rockwell Stream where we collected. Above the highway bridge there is a long stretch of rapids, flowing over small boulders, where *Calopteryx amata* was abundant. Below the bridge the current is slower, the water deeper, with a coarse sandy to gravelly bottom, and here *C. aequabilis* was the commoner species. *Cordulegaster maculatus* and *Ophiogomphus aspersus* were the other dominant species but *O. carolus* was also present. The water was probably too cold for *Calopteryx maculata*.

PICTOU, N. S.

In 1932 our collecting was practically all done along a small stream which crosses the highway about nine miles west of the town, on July 14 and 15. This is a small rapid forest stream with shallow riffles and intermittent pools. For a mile or so above the highway bridge it flows through dense woods but it is wide enough to admit the sunlight to a greater or less extent. Here the water was warmer than that of the Rockwell River and much warmer than the stream near Petitcodiak. *Calopteryx aequabilis* and *C. maculata* fairly swarmed, especially the former, while *C. amata* was absent. Other species taken were *Argia violacea*, *Cordulegaster maculatus*, *Basiaeschna janata* and *Lanthus albistylus*. An *Ophiogomphus* was occasionally seen but not captured.

Farther up the stream narrowed down to a small, cold brook flowing slowly through an open marsh, and appeared to be almost devoid of odonate life, only a single *Nehalennia irene* and a newly emerged *Aeschna umbrosa* having been found.

The other species recorded from Pictou were taken mostly from small ponds or pools, which require no special mention.

BETWEEN NEWCASTLE AND BATHURST, N. B.

(1) St. Margarets, Northumberland Co., July 16, 1932. We spent about twenty minutes at a running stream close to this village. It is similar to the Pictou stream but larger, with

lower banks. There are shallow rapids with small, rounded, projecting boulders and intermittent pools. Strangely enough only a few *Calopteryx* were seen, one *amata* and the rest *maculata*. *Lanthus albistylus* was taken over the boulders and *Ophiogomphus carolus* also captured, while another larger *Ophiogomphus*, probably *rupinsulensis* was followed for some distance, but escaped as did also a single *Hagenius*.

(2) Moor pool, about ten miles south of Bathurst, July 16, 1932. This is a small pond, about 15 yards long and 3-8 feet wide, in a somewhat open part of a black spruce swamp, where the trees are small and not crowded. There is the usual ground vegetation of sphagnum moss, ericaceous shrubs (*Kalmia*, *Chamaedaphne*, *Ledum*), *Wagnera trifolia*, etc. The only dragonflies observed about the pool were *Nehalennia irene*, *N. gracilis*, *Agrion resolutum* and *Leucorrhinia hudsonica*, all in small numbers. The pool is mentioned as an example of a typical moor or muskeg pond in wholly undisturbed surroundings, and also because of its being a station for the very local *Nehalennia gracilis*.

Annotated List of Species.

ZYGOPTERA.

CALOPTERYGIDAE.

1. *Calopteryx maculata* (Beauv.).

N. S.—Digby, 19 VII '09 (J. Russell); Granville Ferry, 16, 20 VII '08 (H. G. P.); Annapolis, 22 VII '21 (H. G. P.); Pictou, 22 VII '14 (W); 9 miles west of Pictou, 14 VII '32, abundant (W); Sydney, C. B., 24 VII '14 (W, Ent. Rec. '14).

N. B.—Rockwell Stream, 10 VII '32, abundant (W); small rapid stream near Gagetown, Queen's Co., 11 VII '32, common (W); St. Margarets, 16 VII '32 (W). Scotch Lake (W. H. M.); Magaguadene River, near mouth, 4 VIII '20 (R. H. Howe).

2. *Calopteryx aequabilis* (Say).

N. S.—Granville Ferry, 16 VII '10 (H. G. P.); Annapolis River, near Middleton, 21 VI '19 (A. G. H.); Nictaux River, 21 VI '19 (A. G. H.); Kentville, 8 VII '13 (H. G. P.); Milford

Sta., Shubenacadie River, 7 VIII '19 (A. H. L.); Elmsdale, Shubenacadie R., 2, 8, 17, VII '20 (A. H. L.); 9 miles west of Pictou, 14 VII '32, very abundant (W).

N. B.—Near Fredericton, 9 VII '32 (W); Rockwell Stream 10 VII '32, very abundant (W); Cardwell twp., Kings, 13 VII '32 (W); Scotch Lake (W. H. M.); St. Andrews, 7 VII '32 (E. S. P.).

These specimens all belong to the eastern race *aequabilis*.

3. *Calopteryx amata* Hagen.

N. B.—Rockwell Stream, 10 VII '32, not uncommon (W); Cardwell twp., Kings, 13 VII '32, abundant (W); St. Margarets, 16 VII '32, 1 ♂ seen (W).

LESTIDAE.

4. *Lestes congener* Hagen.

N. B.—St. Andrews, VIII '16, 2; 16 IX '17, 1 ♂ (A.G.H.).

P. E. I.—Souris (Walker, '17).

5. *Lestes unguiculatus* Hagen.

N. S.—Pictou (Calvert & Sheraton, '94); tenerals about margin of pool on small forest stream, 22 VII '14 (W); Truro (H. G. P.).

N. B.—St. Andrews, VIII '16 (A. G. H.).

P. E. I.—Charlottetown, Souris (Walker, '17).

6. *Lestes uncatus* Kirby.

N. S.—Pictou (Calvert & Sheraton, '94); 22 VII '14, common, tenerals and adults, some in cop.; Eastern Harbour, C. B., 1 VII '17 (A. G. H.); Neil's Harbour, C. B., 29 VII '17, 13 ♂ 26 ♀ (A. G. H.).

N. B.—Near Fredericton, pool on small stream, 1 ♂ 2 ♀ (W); Rockwell Stream, 10 VII '32 (W); Youghall, 5-11 VII '08 (Gibson); St. Andrews, 18 VII '16 (A. G. H.); 1 VII '23, 1 teneral ♂ and many nymphs in pool.

P. E. I.—Charlottetown (Walker, '17).

7. *Lestes disjunctus* Selys.

N. S.—"Nova Scotia" (Selys, '62); Little River, St. Mary's Bay, 3 IX '16 (A. G. H.); Truro, 12 VII '21, 30 VIII '24 (H. G. P.); Wolfville (27 VIII '31); Dingwall, Aspy Bay, C. B., 27 VII '19 (A. G. H., Ent. Rec. '17).

N. B.—Youghall, 6-18 VII '08 (Gibson); St. Andrews, VIII 1 ♀ (A. G. H.); 1 VII '23, 1 juv. ♂ (W); Bocabec Lake, 19 VII '23, tenerals common (W).

P. E. I.—Charlottetown, Souris, Rollo Bay (Walker, '17).

8. *Lestes forcipatus* Rambur.

N. B.—Near Fredericton, small pond beside highway, 9 VII '32, tenerals emerging in large numbers (W).

9. *Lestes rectangularis* Say.

N. S.—Truro, 1 ♂ (H. G. P.).

N. B.—Chamcook Lake, 18 VII '23, 1 juv. ♀ from pond cut off from lake (W).

AGRIONIDAE.

10. *Argia moesta putrida* (Hagen).

N. B.—Chamcook Lake, 18 VII '23, tenerals and mature males on rocky shore of lake and also on pond cut off by railway embankment (W); second Chamcook Lake, 17 VI '32, 1 ♂ 2 ♀ juv.; 26 VI '32, 2 ♂ 2 ♀ (E. S. P.); Gibson Lake, 10 VII '32, 1 ♂ 2 ♀ (E. S. P.).

11. *Argia violacea* (Hagen).

N. S.—Nine miles west of Pictou, 14 VII '32, common (W); Annapolis River at Lawrencetown, 22 VI '19, 1 ♂ 2 ♀ (A. G. H.).

N. B.—Rockwell River, 10 VII '32; Chamcook Lake, 18 VII '23, a few about the deeper end of the pond cut off by railway embankment (W); second Chamcook Lake, 17 VI '32, 1 ♀ juv. (E. S. P.).

12. *Chromagrion conditum* (Hagen).

N. B.—Near St. Andrews, 9 VII '23, 1 ♀ ovipositing in a small cold stream (W); Cardwell twp., Kings, 13 VII '32, 1 ♂ 1 ♀ from small spring-fed pool (W).

13. *Agrion resolutum* Selys.

N. B.—Near Fredericton, 9 VII '32, common about pond beside highway, some pairs in cop.; St. John, 12 VII '32, a few about a quiet recess on the edge of a clear running stream; moor pond about 10 mls. south of Bathurst, 16 VII '32, not numerous but commoner than any other species of Odonata; Youghall, 20 VII '08 (Gibson; Ent. Rec. '08).

14. *Nehalennia irene* (Hagen).

N. S.—Annapolis River, near Middleton, 21 VI '19 (A. G. H.); Pictou, 22 VII '14 (W); 9 miles west of Pictou, 14 VII '32 (W).

N. B.—Near Fredericton, 9 VII '32, common at small stream in pasture, very abundant at pond beside highway, some pairs in cop., ♀s ovipositing, accompanied by ♂; St. Andrews, 15 VII '16 (A. G. H.); 28 VI '23, abundant at small, clay-bottomed pond (W); 1 VII '23, abundant at bog pond; Bocabec Lake, 19 VII '23, frequent (W); Wellington twp., Kent, 16 VII '32, frequent along edge of small stream (W); moor pool south of Bathurst, 16 VII '32, scarce (W).

P. E. I.—Souris (Walker, '17).

15. *Nehalennia gracilis* Morse.

N. B.—Moor pool south of Bathurst, 16 VII '32, 1 ♂ 1 ♀ (W).

16. *Ischnura posita* (Hagen).

N. S.—Nictaux River near Middleton, 21 VI '19, 1 ♂ (A. G. H.).

17. *Ischnura verticalis* (Say).

N. S.—Annapolis River at Lawrencetown, 22 VI '19 (A. G. H.); Annapolis River, near Middleton, 21 VI '19 (A. G. H.); Nictaux River, near Middleton, 21 VI '19 (A. G. H.); Milford Sta., Shubenacadie River, VII '17 (A. H. L.); Shubenacadie River, 7 VIII '19 (A. H. L.); Elmsdale, 2, 22, 28, VI '20, 1, 17 VII '20, 10 VIII '20 (A. H. L.); Bay St. Lawrence, 26 VII '17 (A. G. H.); Truro, 22 VIII '24); Pictou, 22 VII '14 (W); 9 mls. west of Pictou, 14 VII '32 (W); Neil Harbour, C. B., 29 VII '17, abundant (A. G. H.); Plateau River, Cheticamp River, C. B., 4 VIII '17, common (A. G. H.); Dingwall, Aspy Bay, C. B., 27 VII '17, common (A. G. H.); Eastern Harbour, C. B., 1 VII '17 (A. G. H.); Sydney, C. B., 24 VII '14 (W).

N. B.—Near Fredericton, 9 VII '32, quiet pools on small stream (W); French Lake, 10 VII '32, frequent about small sloughs in open marsh (W); Rockwell Stream, 10 VII '32, frequent, apparently from small pools along the shore (W);

St. John River, near Oromocto, and small streams in vicinity, 11 VII '32, common (W); St. Andrews, 23 VI to 19 VII '23, common at many stations (W); 12 VI '32 (E. S. P.); Campo Bello Id., 5 VII '23 (W); Bocabec Lake, 19 VII '23 (W); Scotch Lake (W. H. M.); Cardwell twp., Kings, 13 VII '32, a few about a small, spring-fed pool; Wellington twp., Kent, 16 VII '32 (W); near Newcastle, 16 VII '32, many pruinose ♀s and a few ♂s along the shore of a brackish bay.

P. E. I.—Souris, Rollo Bay (Walker, '17).

18. *Enallagma boreale* Selys.

N. B.—St. Andrews, 28 VI '23, clay-bottomed Typha pond, pair in cop. and 1♂ (W); Bocabec Lake, 19 VII '23, not uncommon.

This species is doubtless much commoner than these two records seem to indicate. We found it abundant at a bog lake near Lake Temiscouata, Que., 25 miles from the New Brunswick boundary line.

19. *Enallagma hageni* (Walsh).

N. S.—Annapolis River, 21 VI '19 (A. G. H.); Nictaux River, near Middleton, 21 VI '19 (A. G. H.); Sydney, C. B., 24 VII '14 (W. Ent. Rec. '14); Dingwall, Aspy Bay, C. B., 27 VII '17, common (A. G. H.).

N. B.—Near Fredericton, 9 VII '32, abundant about pond beside highway and quiet weedy parts of small stream and adjoining marsh, many pairs in cop.; 10 VII '32 (W); French Lake, 10 VII '32, common in open marsh surrounding lake; Rockwell River, 10 VII '32, stray specimens along rapid part of river; St. John River, 10 miles southeast of Fredericton, 11 VII '32, common about marshy lagoons close to river; also taken in several other marshy places along the highway 15 to 20 mls. below Fredericton (W); St. Andrews, 30 VI '23, 1 ♂ at bog pond (W); Bocabec Lake, 19 VII '23, fairly common (W); Scotch Lake, 28 VIII '04 (W. H. M.); Youghall, 2 to 20 VII 08, common (Gibson).

P. E. I.—Charlottetown, Souris (Walker, '17).

20. *Enallagma ebrium* Hagen.

N. S.—Pictou, abundant (Calvert & Sheraton, '94); 22 VII '24 (W); Elmsdale, 17 VII '20 (A. H. L.).

N. B.—Chamcook Lake, 6 VII '23, not uncommon at pond cut off by embankment (W); second Chamcook Lake, 26 VII '32 (E. S. P.); 15 mls. north of Shediak, common on quiet brook in open pasture (W).

21. *Enallagma exsulans* (Hagen).

N. S.—Elmsdale, 28 VI '20, 10 VIII '19 (A. H. L.); Milford Sta., Shubenacadie River, 7 VIII '19 (A. H. L.).

N. B.—Rockwell Stream, 10 VII '32, not uncommon, all of rather small size, 1 pair in cop. (W); Chamcook Lake, 17 VIII '27, 2 ♂ 2 ♀ (W. S. H.); second Chamcook Lake, 26 VI '32, 1 ♂ juv. (E. S. P.).

22. *Enallagma minusculum* Morse.

N. S.—Lake Kedgemagooge, 2 VIII to 11 IX (E. B. Wardon).

N. B.—Scotch Lake, 7 VII (W. H. M.; Ent. Rec. '07); Bocabec Lake, 19 VII '23, ♂s abundant over shallow water of bay (W).

23. *Enallagma civile* (Hagen).

N. S.—Plateau River, Cheticamp, C. B., 4 VIII '17, 5 ♂ 4 ♀ (W. G. H.; Ent. Rec. '07).

N. B.—Bocabec Lake, 19 VII '23, not uncommon among rushes over shallow water (W); Chamcook Lake, 17 VIII '27, 4 ♂ (W. S. H.); near Newcastle, shore of brackish inlet, 16 VII '32 1 ♂ (F. P. I.).

P. E. I.—Souris (Walker, '17).

24. *Enallagma vesperum* Calv.

N. B.—Chamcook Lake, 17 VIII '27, 1 ♂ (W. S. H.).

ANISOPTERA.

AESCHNIDAE.

25. *Boyeria vinosa* (Say).

N. S.—Truro, 1 ♂ (H. G. P.); 29 VIII '28, 1 ♀ (H. G. P.); nine miles west of Pictou, 14 VII '32, a half-grown nymph was found under a stone at edge of current. It was too early in the season for the adults.

This species is probably common on most of the running streams in the maritime provinces but the adults must be sought in August and early September.

26. *Basiaeschna janata* (Say).

N. S.—9 miles west of Pictou, 14 VII '32, fairly common. They flew swiftly up and down the stream within a few feet of the water, following one bank or the other but frequently crossing over and sometimes chasing one another. All captured on the river were males but a female was taken hawking in the woods nearby (W).

N. B.—Rockwell Stream, 10 VII '32, 2 ♂ 1 ♀ taken along the river banks, others seen; stream near Gagetown, 11 VII '32, 1 ♀; Chamcook Lake, 6 VII '23, a few individuals patrolling edge of lake and one or two flying over the adjacent pond and in the woods nearby.

The specimens from Pictou and the Rockwell River were old though not much worn; the season was evidently nearly over when they were taken. It is well over by this time in Ontario, south of Lake Nipissing.

27. *Aeschna eremita* Scudd.

N. S.—Annapolis Co., 14 VIII '08, 1 ♂ (H. G. P.); Kentville, 4 VIII '19 ♂ (H. G. P.); Pembroke Lake, near Grand Étang, C. B., 2 IX '19, 10 ♂ 1 ♀ (A. G. H.); Dingwall, Aspy Bay, C. B., 27 VII '17, 1 ♂ (A. G. H., Ent. Rec. '17).

28. *Aeschna interrupta interrupta* Walk.

N. S.—"Nova Scotia" (Walker, '12); Truro, 1 ♂ 1 ♀ (H. G. P.); Dingwall, Aspy Bay, C. B., 27 VII '17, 1 ♂ 1 ♀ (A. G. H., Ent. Rec. '17).

P. E. I.—Souris (Walker, '17).

29. *Aeschna clepsydra* Say.

N. S.—Kedgemagooge, 2 VIII–11 IX, 1 ♂ (E. B. Wardon).

30. *Aeschna canadensis* Walk.

N. S.—Truro, 2 X '13, 14 VIII 24, common (H. G. P.); Pictou (Walker, '12; Calvert & Sheraton, '94, as *A. clepsydra*); Kedgemagooge, 2 VIII–11 IX (R. H. Howe); Dingwall, Aspy Bay, C. B., 27 VII '17 (A. G. H., Ent. Rec. '17).

N. B.—Little River, St. Mary's Bay, 3 IX '16 (A. G. H.); St. Andrews (Walker, '12); 18-21 VIII '18 (A. H. L.); 22 VIII '27 (W. S. H.); 23 VI '23, full grown nymphs and earlier stages found in several of the small bog ponds; 8 VII '23, 2 exuv.; Bocabec Lake, 19 VII '23 (W).

31. *Aeschna verticalis* Hagen.

N. B.—St. Andrews, 16 IX '17, 2 ♂ (A. G. H.).

32. *Aeschna subarctica* Walk.

N. S.—Pictou (Walker, '12).

33. *Aeschna coerulea septentrionalis* Burm.

N. S.—"Nova Scotia" (Hagen, '61).

34. *Aeschna umbrosa* Walk.

N. S.—Truro, common; 28 VIII '27, 2 IX '13; 20 VIII '24, 3 IX '24 (H. G. P.); Bass River, Colchester Co., 26 VIII '21, nymph, penult. stage (A. H. L.); Pictou (Calvert & Sheraton, as *constricta*; Walker, '12); 9 miles west of Pictou, 14 VII '32, ♂ just emerged (W); mountain lake behind Grand Étang, C. B., 2 IX '17, 6 ♂ (A. G. H.); Pembroke Lake, near Grand Étang, C. B., 2 IX '17 (A. G. H.); Eastern Harbour, C. B., (A. G. H.).

N. B.—Bartiloque, 23 VIII '18 (A. H. L.); St. Andrews, 21-30 VIII '17 (A. G. H.); 28 VI '27 (W. S. H.); 12 VII '23, nymphs common in small forest brooks and spring runs, and several full grown ones found in a short drainage ditch from a bog pond (W); small forest stream near Bocabec Lake, 19 VII '23 (W).

P. E. I.—Charlottetown, Souris (Walker, '17).

35. *Aeschna constricta* Say.

N. S.—"Nova Scotia" (Walker, '12); Granville Ferry, 14 VI '08, 1 ♂ (H. G. P.); Truro, 24, 30 VIII '24, 2 IX '24, (H. G. P.).

The date of the Granville Ferry specimen is probably erroneous as *constricta* is a late summer and autumnal species.

36. *Anax junius* (Drury.)

N. S.—Truro, 24 VIII '25, 1 ♀ (H. G. P.); Pictou, 22 VII '14, a single individual observed flying over a small pond on edge of a wood (W).

GOMPHIDAE.

37. *Hagenius brevistylus* Selys.

N. S.—Shubenacadie River, young nymph (A. H. L.).

N. B.—Scotchtown wharf, Grand Lake, 28 VII '26, 1 teneral ♀ (A. H. L.); St. Margarets, 16 VII '32, one seen at running stream (W).

38. *Ophiogomphus carolus* Needh.

N. B.—Rockwell Stream, 10 VII '32, frequent, flying over riffles and resting on foliage along the banks (W); Cardwell twp., Kings, 13 VII '32, 1 ♂ and an exuvia (W); St. Margarets, 16 VII '32, 2 ♂ (W).

N. S.—Nine miles west of Pictou, 14 VII '32, 1 exuv. (W); Shubenacadie River, nymph penult. stage, probably this species (A. H. L.).

39. *Ophiogomphus aspersus* Morse.

N. B.—Cardwell twp., Kings, 13 VII '32, rather common along a cold stream, 8 taken, all males (W).

40. *Lanthus parvulus* (Selys.)

N. S.—"Nova Scotia" (Selys, '54).

41. *Lanthus albistylus* (Hagen).

N. S.—9 mls. west of Pictou, 14 VII '32, fairly common over shallow rapids, flying close to the water and resting on boulders (W).

N. B.—St. Margarets, 16 VII '32, 2 ♂ from small rapid stream (W).

42. *Gomphus exilis* Selys.

N. S.—Elmsdale, Shubenacadie River, 28 VI '20, 1 ♀ juv., 2, 7 VII '20, common, 13 VIII '19, 1 ♀ (A. H. L.); 12, 13 VI '22, full-grown nymphs (A. H. L.).

N. B.—Chamcook Lake, 6 VII '23, teneral ♂ and several exuviae from rocks and timbers of a wharf; 18 VII '23, common at the same locality; Bocabec Lake, 19 VII '23, common along the shore, males only noticed (W).

43. *Gomphus brevis* Hagen.

N. S.—Elmsdale, Shubenacadie River, 12, 13 VII '32, young nymphs of various stages (A. H. L.). These might possibly belong to *G. abbreviatus* Hagen, which is regional but has never been taken in Canada. No satisfactory characters have been given for the separation of nymphs of these two related species.

N. B.—Rockwell Stream, 10 VII '32, 2 ♂ 1 ♀ (F. P. Ide & E. H. Walker).

44. *Stylurus scudderi* (Selys)?

N. S.—Elmsdale (A. H. L.): a few young Stylurus nymphs were found in a bottle containing a large number of small gomphine nymphs, mostly *G. brevis*. The width of the abdomen is too great for any other known species of Stylurus but I have no authentic nymphs of *scudderi* young enough for close comparison. I believe the determination, however, to be almost positive.

CORDULEGASTERIDAE.

45. *Cordulegaster maculatus* Selys.

N. S.—Cape Breton Island (Selys, '78); Annapolis Co., 23 VI '09, 1 ♂ (H. G. P.); Granville Ferry, 6 VII '09, 1 ♂ (H. G. P.); 9 mls. west of Pictou, 14 VII '32, very common along small, rapid forest stream, 1 ♀ ovipositing (W).

N. B.—Scotch Lake (W. H. M.); Rockwell Stream, 10 VII '32, common; the males patrolling the edge of the stream swiftly; 1 ♀ taken while ovipositing (W); small rapid stream near Gagetown, 11 VII '32, ♂ common; Cardwell twp., Kings, 13 VII '32, common along a cold clear stream (W); St. Andrews, 1 ♂ (A. G. H.).

46. *Cordulegaster diastatops* Selys.

N. S.—Pictou (Calvert & Sheraton, '94).

N. B.—St. Andrews and vicinity of Chamcook Lake, 23 VI to 19 VII '23, not uncommon along all the small cold brooks and spring runs, prefers streams in the open but also occurs in the woods (W); Rockwell Stream, 10 VII '32, 1 ♂ (E. H. Walker); small stream near Gagetown, 11 VII '32, 1 ♀ ovipositing (W); near St. John, 12 VII '32, 1 ♂ patrolling a small brook for a distance of a few yards only (W).

The position of the body assumed by the female of this species in ovipositing is less vertical than in *C. maculatus*.

LIBELLULIDAE.

CORDULIINAE.

47. *Cordulia shurtleffi* Scudd.

N. S.—"Nova Scotia" (Hagen, '61, as *C. bifurcata*); Pictou 22 VII '14, 1 ♀ seen (W).

N. B.—Youghall, 18 VII '08, 1 ♂ (Gibson); Bocabec Lake, 19 VII '23, ♂s common, flying over zone of emergent vegetation, especially near its outer edge (W).

This species is doubtless much more abundant than is indicated by these meagre records.

48. *Dorocordulia lepida* (Hagen).

N. B.—Nashwaak, near Fredericton, 26 VII '22, 1 ♂ (L. J. S., in Can. Nat. Coll.); French Lake, 10 VII '32, 1 ♂ 2 ♀, incl. pair in cop. in shelter of shrubs on edge of wide marsh (W).

49. *Dorocordulia libera* (Selys).

N. B.—Campo Bello Is., 5 VII '23, 1 ♀ (W); Bocabec Lake, 19 VII '23, fairly common over the zone of emergent vegetation (W).

50. *Somatochlora walshii* (Scudd.).

N. S.—Truro, 3 IX '28, 1 ♂ (H. G. P.); Pictou (Calvert & Sheraton, '94).

N. B.—Near St. Andrews, 6-18 VII '23 (Walker '25): males flew over an open boggy portion of a cold stream.

51. *Somatochlora minor* Calvert.

N. S.—Cape Breton Island (Walker, '25).

N. B.—Small rapid stream near Gagetown, 11 VII '32, 1 ♂ (W).

52. *Somatochlora elongata* (Scudd.).

N. S.—"Nova Scotia" (Hagen, '61); Digby, 3 IX '08 1 ♂ (J. Russell); Annapolis Co., 6 IX '08, 1 ♂ (H. G. P.); Granville, 2 IX '09, 1 ♂ (H. G. P.); Bass River, Colchester Co., 21-26 VIII '21 (A. H. L., Walker '25).

N. B.—Head of St. John River (Walker, '25); near St. Andrews, 9 VII '23 (Walker, '25).

P. E. I.—Rollo Bay, 21 VIII '15 (Walker '17).

53. *Somatochlora tenebrosa* (Say).

N. S.—"Nova Scotia" (Hagen, '61): South Milford, 9 IX '27, 1 ♂ (R. H. Howe).

54. *Somatochlora franklini* (Selys).

N. B.—St. Andrews, 9 VII '23 (Walker, '25).

55. *Somatochlora kennedyi* Walk.

N. B.—French Lake, 10 VII '32, pair in cop. from woods near open marsh (F. P. Ide); St. Andrews and vicinity, 26 VI '18 (A. G. H.); 25 VI to 12 VII '23 (Walker, '25).

56. *Somatochlora incurvata* Walk.

N. S.—Kings Co., 4 VIII '17, 1 ♂ 1 ♀ (H. G. P.); Truro, 2 ♀ (H. G. P.).

Previously known only from Chippewa Co., Mich., and Lake Nipissing, Ont.

57. *Somatochlora forcipata* Scuss.

N. S.—"Nova Scotia" (Hagen, '61); Halifax (Walker, '25).

N. B.—St. Andrews and vicinity of Chamcook Lake, 28 VI to 18 VII '23 (Walker, '25); Mirimichi Bay, 17 VII '18 (A. G. H.).

58. *Somatochlora cingulata* (Selys.)

N. B.—Bocabec Lake, 19 VII '23, 1 ♀, just emerged, with exuv. (Walker, '25).

59. *Helocordulia uhleri* (Selys).

N. S.—9 mls. west of Pictou, 14 VII '32, 1 ♂ from small rapid stream (W).

N. B.—Rockwell Stream, 10 VII '32, 2 ♂ taken over gentle rapids (W); St. Andrews, 1 VII '23, 1 ♂ (A. B. Klugh).

60. *Tetragoneuria canis* (McLachlan).

N. S.—Truro, 7 VII '26, 2 ♂ (H. G. and M. D. Payne).

61. *Tetragoneuria spinigera* (Selys.)

N. B.—Near Fredericton, 9 VII '23, 2 ♂ flying back and forth and hovering over a small stream crossing the highway; they kept over the smooth water just above a stretch of riffles (W); French Lake, 10 VII '32, 1 ♂ taken while flying in a sunny opening in a wood adjoining the open marsh (W); second Chamcook Lake, 26 VI '32, 3 ♂ (E. S. P.).

62. *Tetragoneuria cynosura simulans* (Say) Muttk.

N. S.—"Nova Scotia" (Hagen, '75, as *Cordulia semiaquea*).

N. B.—French Lake, 10 VII '32, 2 ♂ from woods adjoining marsh (F. P. Ide); near Chamcook Mt., 1 VII '23, 2 ♂ flying over grassy knoll at foot of mountain (W); near Chamcook Lake, 6 VII '23, not uncommon, flying over wood road and in openings in woods, a few patrolling the pond adjacent to the lake (W); second Chamcook Lake, 26 VI '32, 3 ♂ (E. S. P.); Bocabec Lake, 19 VII '23, common, flying over the sedges and horsetails growing in shallow water (W).

The specimens from French Lake and the second Chamcook Lakes have a very large, dark patch at the base of the hind wings.

63. *Didymops transversa* (Say).

N. S.—Elmsdale, 22 V '20, 4 full grown nymphs; 13 VIII '19, nymph, penult. stage (A. H. L.).

N. B.—St. John River, near Oromocto, 11 VII '23, 1 ♂ patrolling edge of river (W); McAdam, 22 VI '23, patrolling shore-line of large pond; Chamcook Mt., 1 VII '23, many individuals flying along southern slope of mountain in shelter of woods, up and down the road, or back and forth in small sunny clearings. These individuals doubtless came from Chamcook Lake, where on 6 VII '23 a male was taken and others observed flying swiftly up and down over the water; and exuvia found but no adults seen.

64. *Macromia illinoiensis* Walsh.

N. S.—Elmsdale, 1 VI '20, 1 full-grown and 1 penult. stage nymph; 20 VIII '19, 1 penult. stage, 2 juv. (A. H. L.).

LIBELLULINAE.

65. *Libellula quadrimaculata* L.

N. S.—Digby, 19 VII '07, (J. Russell); Granville Ferry, 6 VII '09 (H. G. P.); Pictou (Calvert & Sheraton, '94); 22 VII '14, abundant, some in cop.; 9 mls. west of Pictou, 14 VII '32, many flying over a small trickle of water, with intermittent pools, on a boggy slope; Roundhill, 24 VIII '19 (A. G. H.); Eastern Harbour, C. B., 1 VII '17 (A. G. H.).

N. B.—Near Fredericton, 9 VII '32, a few flying over the pond beside the highway (W); French Lake, 10 VII '32, a few seen on edge of the marsh in shelter of willows (W); marshy overflow from a small, rapid stream near Gagetown, 11 VII '32, ♀ ovipositing (W); St. John, 12 VII '32, several in openings in woods and over shallow pools in an open sphagnum bog (W); McAdam, 22 VI '23, several flying over marshy spot on bank of small lake (W); St. Andrews and vicinity, 26 VI to 19 VII, common at all ponds and quiet parts of small streams, especially where aquatic vegetation is abundant (W); 28 VI '27 (W. S. H.); Campo Bello Is., 5 VII '23 (W); Bocabec Lake, 19 VII '23, very common over the shallow warm water and the marsh, all the specimens old and worn; Youghall, 2 VII '08 (Gibson); small stream in Wellington twp., Kent, 16 VII '32 (W); near Newcastle, a few flying over a brackish inlet, near the shore, 16 VII '32 (W).

P. E. I.—Charlottetown, Souris (Walker, '17).

66. *Libellula pulchella* Drury.

N. B.—French Lake, 10 VII '32, one was seen distinctly but not captured, near the marsh surrounding the lake.

67. *Libellula exusta exusta* Say.

N. S.—Digby, 3 VI '08 1 ♀ (J. Russell).

This is the only specimen of the race *exusta* that I have seen from Canada. It is small even for this race, the abdomen measuring 21.5 mm. and the hind wing 28 mm.

68. *Libellula lydia* Drury.

N. B.—Near St. Andrews, 6 VII '23, 1 ♂ from puddle on roadside.

69. *Sympetrum decisum* (Hagen).

N. S.—Annapolis Co., 29 VII 20; Truro (H. G. P.), 24 VII '19 (M. D. Payne); Bass River, Colchester Co., 13, 17 VIII '21 (A. H. L.); Pictou (Calvert & Sheraton, '94, as *rubicundulum*); 22 VII '14, common, mostly tenerals but some pairs in cop. (W); Neil Harbour, C. B., 29 VII '17, tenerals (A. G. H.); Plateau River, Cheticamp, C. B., 5 VIII '17 (A. G. H.).

N. B.—Little River, St. Mary's Bay, 3 IX '16 (A. G. H.). Near Fredericton, 9 VII '32, emerging from small weedy pond in wet pasture, a few tenerals also at highway pond (W); French Lake, 10 VII '32, tenerals in large numbers in open marsh and numerous adults flying and resting in shelter of willows at edge of marsh (W); Cardwell twp., Kings, 16 VII '32, a few adults flying about the spring-fed pool, near the river (W); near St. Andrews, 8 VII '23, nymphs abundant in bog pond and adults emerging (W); St. Andrews, VIII '16, 18 IX '17 (A. G. H.); 20 VIII '18, 16, 18 IX '17 (A. H. L.); 7, 22 VIII '27 (W. S. H.); Scotch Lake, 7 VII '04, 7 IX '04 (W. H. M.); Youghall, 3 VII '08, tenerals (Gibson).

P. E. I.—Charlottetown, Souris (Walker, '17).

70. *Sympetrum obtrusum* (Hagen).

N. S.—Granville Ferry, 20 VII '08; Truro, 1 VIII '25; Pictou (Calvert & Sheraton, '94); 22 VII '14, 1 ♂ juv. (W); Plateau River, Cheticamp, C. B., 5 VIII '17, 1 ♂ juv. (A. G. H.).

N. B.—St. Andrews, 20 VIII '18, (A. H. L.); 16, 18 IX '17 (A. G. H.); Logieville, 26 VIII '18 (coll.?).

P. E. I.—Charlottetown, Souris (Walker, '17).

71. *Sympetrum costiferum* (Hagen).

N. S.—Milton, Yarmouth, 3 IX '20, 6 ♂ (A. G. H.); Granville Ferry, 21 VII '10, 1 ♀ (H. G. P.); Truro, 31 VIII '24, 20 VIII '25. (H. G. P.)

N. B.—Scotch Lake (W. H. M.).

72. *Sympetrum semicinctum* (Say).

N. S.—Truro, 4 IX '29, 1 ♂ (M. D. Payne), 30 VIII '25, 31 VII '26.

N. B.—Scotch Lake (W. H. M.).

73. *Sympetrum danae* (Sulz.)

N. B.—St. Andrews, VIII '16, 1 ♂ (A. G. H.); Bocabec Lake, 19 VII '23, tenerals flying in company with *S. decisum* but far less plentiful (W).

74. *Leucorrhinia hudsonica* (Selys.)

N. S.—Nictaux River, 29 VI '19 (A. G. H.); Pictou (Calvert & Sheraton, '94); 22 VII '14, fairly common (W).

N. B.—Near Fredericton, pond beside highway, 9 VII '32, 1 ♂, a few others seen; St. Andrews, 10 VI '17, 1 ♂ juv.; 2 VI '19, 1 ♀; 26, 29 VI '19, common; 15 VII '16, 6 ♂ (A. G. H.); 25-30 VI '23, occasional in sunny openings in woods and about bog ponds, not common this season but usually frequent; 12-16 VI '32, 5 ♂ (E. S. P.).

P. E. I.—Souris (Walker, '17).

75. *Leucorrhinia glacialis* Hagen.

N. S.—Cape Breton Is. (Hagen, '90).

N. B.—Scotch Lake (W. H. M.).

76. *Leucorrhinia proxima* Calvert.

N. S.—Pictou (Calvert, '90; Calvert & Sheraton, '94); 22 VII '14, common (W).

N. B.—St. Andrews, 26 VI '18, 15 VII '16 (A. G. H.); clay-bottomed pond at foot of Chamcook Mt., 28 VI '23, a few among a large number of the next species (W); bog pond near Chamcook Lake, 16 VII '23, not numerous (W); Bocabec Lake, 19 VII '23, pruinose males common and of large size.

77. *Leucorrhinia intacta* (Hagen)

N. S.—Pictou (Calvert & Sheraton, '94); 22 VII '14 (W).

N. B.—Near Fredericton, pond beside highway, 9 VII '32, ♂s abundant (W); French Lake, 10 VII '32, a few in shelter of willows at edge of marsh and one or two over open water (W); St. Andrews, 26 VI to 1 VII, common about all bog ponds, all mature (W); 29 VI '32 (E. S. P.); clay-bottomed pond at foot of Chamcook Mt., 28 VI '23, abundant (W); Bocabec Lake, 19 VII '23, a few but outnumbered here by *L. proxima.*

P. E. I.—Souris (Walker, '17).

78. *Pantala hymenea* Say.

N. B.—St. Andrews, 18 IX '30, 2 full grown nymphs were taken from a cement tank and others of various sizes were found but not preserved (M. W. Smith).

THE ACTION OF SOME MERCURY SALTS ON THE INTESTINE OF THE CAT.

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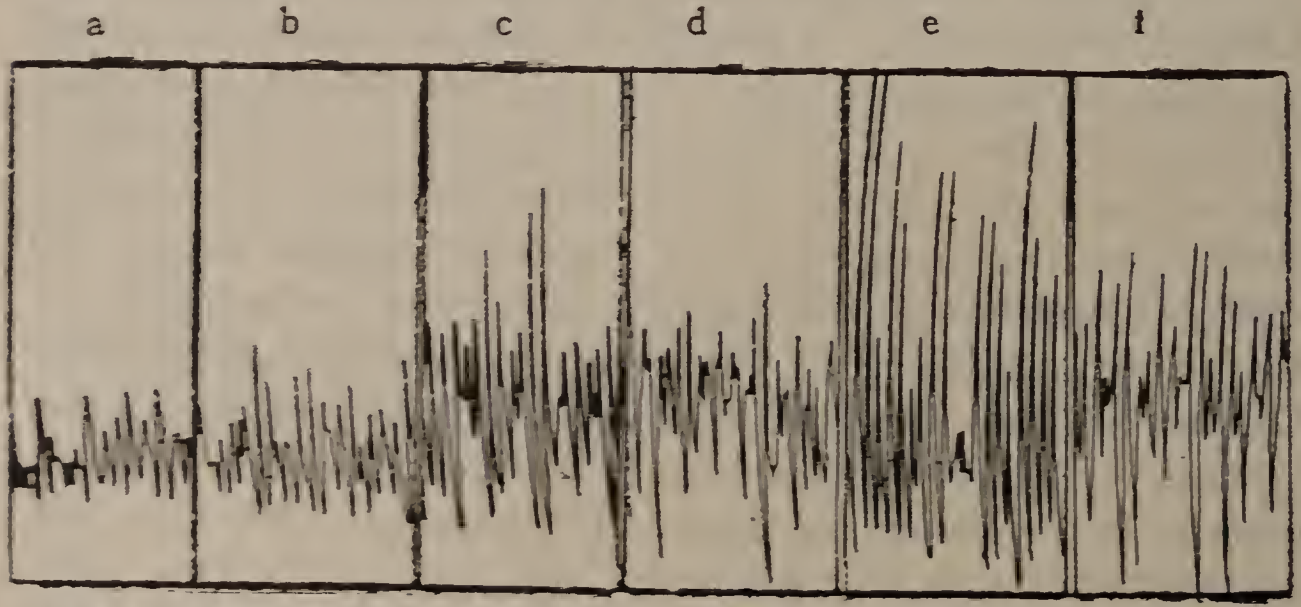
ABSTRACT.

Mercury salts cause an increase in intestinal movements as a result of irritation to the intestinal mucosa. The intensity of action increases with a rise in concentration. The mercurous require a longer time to produce their effects than the mercuric salts. The increase in the fluid of the intestine is not due to a secretion of succus entericus, since no ferments were detected.

The salts of mercury, such as mercurous chloride (calomel) and mercuric chloride, differ in their actions on the intestine. Calomel, in therapeutic doses, causes no damage to the intestine, while mercuric chloride, in cases of poisoning, irritates the intestinal mucosa. The extent of this varies with the concentration, the amount of the drug taken, and the time allowed for it to act. Calomel, in comparatively big doses, produces no harmful effects. In mercuric chloride poisoning diarrhoea is always a prominent symptom, and the intestinal contents are often blood-stained. This indicates considerable damage to the intestine. The mercuric chloride reaction is more intense than that of calomel, since it is very soluble, not only in water, but also in body fluids and in an excess of protein. Calomel, on the other hand, is comparatively insoluble, but its solubility rises in the presence of sodium chloride, which is present in the intestinal fluid. It seems probable that the ionised mercury is responsible for the purgative action, since mercuric salts are more active than mercurous, and insoluble mercury salts, such as mercury sulphide, are inactive. The solubility of mercuric chloride in water, at 15°C., is 5.73%, and at 100°C., 53.96%. The corresponding solubilities for calomel are 0.00031% and 0.01%. The solubility of calomel at 37°C. must lie somewhere between these extremes. To test the action of a mercury salt on the intestine, various concentrations of mercuric chloride were selected.

METHOD.

Cats, anaesthetised with chloralose (0.1 g. per kg.) were used. Intestinal loops of 10 to 12 cms. length were prepared as described elsewhere.[1] To keep the temperature of the animal as nearly normal as possible, the lower half of its body was submerged in a bath of Ringer's fluid kept at 37°C. In each cat the loop was filled with measured quantities of 0.9% sodium chloride for obtaining normal movements, and with corresponding quantities of mercury solutions of known concentration, in 0.9% sodium chloride, for comparison. The time allowed for any solution to act was the same in all cases, and was usually limited to fifteen minutes. The fluid recovered at the end of each period was measured to determine whether absorption or secretion had taken place. Only a section of the movements of each period are reproduced in Figure I.



0.9% NaCl — 0.01% $HgCl_2$ in 0.9% NaCl — 0.02% $HgCl_2$ in 0.9% NaCl — 0.9% NaCl — 0.04% $HgCl_2$ in 0.9% NaCl — 0.9% NaCl

Fig I.

RESULTS.

In Fig. Ia is seen the type of movement obtained from the sodium chloride. Fig. Ib shows the effect of a 0.01% solution of mercuric chloride, which was taken as the lowest effective concentration. There was a slight but perceptible increase in amplitude but no increase in rate. This solution was replaced by another of double concentration (0.02% $HgCl_2$), (Fig. Ic.) The amplitude is greatly increased and the tone to a lesser extent. On removal of the mercury solution a cloudiness was perceptible in it, and on microscopic examination numerous epithelial cells were found. The intestinal lumen was next washed with 0.9% sodium chloride, to remove as much as possible of the mercury adherent to the mucosa, and the movements were tested after this with the sodium chloride in the intestine (Fig. Id). The intestine showed almost as much activity as when the mercury solution was acting. Increasing the mercury salt concentration to 0.04% a very pronounced increase was observed in the movements, with practically no change in the "diastolic" level of the intestinal movements (Fig. Ie). There seemed to be no diminution in the activity of the intestine as time went on. After washing out the mercury solution and replacing this by the neutral sodium chloride the increased activity of the intestine persisted (Fig. If). These movements were almost entirely peristaltic. Observation of the loop showed that at times the contractions were so strong that the intestine became almost bloodless, and the movements were more of the nature of spasms of the whole length of the loop. The higher concentrations of mercuric chloride produced very severe damage to the mucous membrane. The fluids, on removal, were found to be quite turbid and on standing deposits, consisting of large clumps of epithelial cells, settled out. Occasionally the fluids were blood-stained. Repeated washing of the mucosa with 0.9% sodium chorlde did not restore the motility of the intestine to its initial level. Instead, the increased activity continued for several hours, though not as marked as when the mercury solution was acting on the intestine. This after-effect was probably due to the irritation of the mucosa. With the lower concentrations of mercury the after-effect was not so prominent or even absent

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[1] Dreyer, *J. Pharmacol.*, 36, 477 (1929).

with the minimal effective concentration (0.01%), depending probably on the degree of irritation. It is probable that if a segment in the upper intestine became overactive from mercury stimulation, such a segment acted as a pacemaker for the intestine below. Further, since with therapeutic doses of calomel the mercury is inactivated to sulphide on reaching the lower part of the small intestine and the large intestine, the pacemaker hypothesis may account partly for the stimulant action of mercury salts, in therapeutic doses, on the lower intestine. The power of the intestinal epithelium to absorb fluid is not abolished by the very dilute solutions of mercuric chloride, but the absorption of water is absent with the higher concentrations. It should be pointed out that the increase in fluid in the intestine is not sufficient to account for the great increase in motility, for when known amounts of 0.9% sodium chloride were run in and records of movements were taken. bigger movements due to increased pressure were found, but never to the same degree as when a mercury solution was acting. Further, in animals deprived of water for twelve hours, an increase in movement always followed the application of mercury solutions, without, or with only a slight increase in the volume of fluid. (Table 1). When, however, an increase in fluid does occur, the irritant action of the mercury salt is aided by the increased intestinal pressure. But when precautions were taken to prevent any appreciable rise in pressure, the movements were still increased by the mercury solutions. It will be seen from Fig. If that the irritation of the intestinal mucosa persists, after removal of the stronger mercury solutions, even after a thorough washing of the intestinal mucosa, and that instead of absorption, "secretion" is now present.

The action of calomel on the intestine is milder and is slower in onset than that of mercuric chloride, but once it begins to act, the effects resemble those of the lower concentrations of mercuric chloride. Suspensions of calomel left in contact with the intestinal mucosa for periods lasting from one to two hours cause severe damage to the mucosal cells,

Table 1.

Cat. Chloralose. Vagi, and splanchnic nerves and adrenals intact. Loop of upper jejunum. $HgCl_2$ solutions made up in 0.9% NaCl. Solutions left in for fifteen minutes.

Fluid.	Amount Put in.	Amount Recovered.	
(1) 0.9% NaCl	11.0 c.c.	9.0 c.c.	absorption
(2) 0.01% $HgCl_2$	11.0 c.c.	10.3 c.c.	absorption less than in 1
(3) 0.02% $HgCl_2$	11.0 c.c.	11.6 c.c.	increase in fluid
(4) 0.9% NaCl	11.0 c.c.	10.5 c.c.	absorption
(5) 0.04% $HgCl_2$	11.0 c.c.	11.8 c.c.	increase in fluid
(6) 0.9% NaCl	11.0 c.c.	11.5 c.c.	increase in fluid

and here, too, shreds of mucous membrane can be found in the intestinal fluid. The irritation so produced leads to an increase in the intestinal fluid. The fluids recovered from the intestine following the action of mercury salts contain none of the enzymes characteristic of succus entericus. Repeated tests for erepsin and invertase proved negative. In all cases the mercury was inactivated before testing for ferments. This points to the fact that the increased "secretion" was not one of succus entericus, but was probably of the nature of an exudate.

OBSERVATIONS OF THE SEASONAL CHANGES IN THE MARINE ALGAE IN THE VICINITY OF HALIFAX, WITH PARTICULAR REFERENCE TO WINTER CONDITIONS.

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(Received April 10, 1933.)

ABSTRACT.

Marine algae found in winter were studied at Halifax during the two seasons 1930-31 and 1931-32. In this study was included also an investigation of the succession of algal crops in the vicinity and especially at a lagoon outlet where it was possible to observe the sublittoral flora at all times. These winter studies were supplemented by the spring, summer, and autumn collecting of about seven years. No exclusively winter forms were found. The seasonal succession of crops in brief is as follows: a comparatively barren period in early autumn; dominance of an *Ilea-Scytosiphon—Dumontia—Polysiphonia* association until the middle of January; a *Monostroma—Spongomorpha—Bangia* association until the end of April; and from then on an association in which *Laminaria, Chorda, Polysiphonia*, etc., at first are dominant but are gradually replaced by *Chordaria* which becomes dominant by June. In late August and early September there is a general clearance of all annuals and a short return to the semi-barren period. Species found at Halifax are listed. For each species, the frequency, habitat, and season are given together with notes on other observations.

Introduction.

A survey of the marine algae of the Maritime Provinces has been conducted under the auspices of the Biological Board of Canada and the National Research Council of Canada. Up to the autumn of 1930, most of the work had been carried on in the summer. Apart from a few casual observations, no systematic study of winter forms had been made. Without a more definite knowledge of winter conditions, the completeness of a taxonomic list would have been very uncertain, and it was therefore necessary to make a more thorough examination of the winter flora. This was done at Halifax and forms the basis of the present report. The yearly succession of crops was observed in detail in the main outlet of the large lagoon near Thrumcap. Other places were less regularly examined to supply comparative information and these furnished additional data concerning many species in Halifax Harbour. The appearance of the various algal seasons with their characteristic succession of crops as found in the outlet is given in outline, the information gained concerning the principal algae of the harbour is tabulated, and additional notes are given where necessary and possible.

A study of the sub-littoral algae is often difficult at any season and in winter even the littoral zone is not easy of access. In view of the obvious difficulties in winter collecting it is not surprising that up to the present few observations on marine algae have been made at this season. Professor B. M. Davis[1] has published an important detailed account of the marine algae of Woods Hole. In this he includes remarks on the seasonal distribution of each species but the content would imply that no exhaustive observations had been made in winter. In any event the Woods Hole region, though similar in many respects to Halifax Harbour, could not be regarded as an exact parallel. Dr. M. A. Howe[2] has published a short list of plants collected in Long Island Sound on February 7, and March 5, 1914. Mr. Roy M. Whelden[3] in "The Maine Naturalist" treats of *Dumontia filiformis* growing in a pool from September to June. Apart from these there is very little information recorded concerning specific winter conditions on this coast. Other records contain casual references to winter conditions. Collins[4] and Farlow[5] each frequently give seasonal and ecological descriptions in their works. Hoyt[6]

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[1] Davis, B. M. A Biological Survey of the Waters of Woods Hole and Vicinity. Part I, Sec. II, Part II, Sec. IV. Bulletin of the Bureau of Fisheries Vol. XXXI. Washington, 1913.

[2] Howe, M. A. Some Midwinter Algae of Long Island Sound. Torreya XIV. 6 June 1914.

[3] Whelden, Roy M. Observations on Dumontia filiformis. The Maine Naturalist. VIII. 4. 1928.

[4] Collins, F. S. The Green Algae of North America. Tufts College Studies. Vol. II, No. III. 1909.

[5] Farlow, W. G. The Marine Algae of New England and Adjacent Coast. Report of U. S. Fish Commission for 1879. 1881.

[6] Hoyt, W. D. Marine Algae of Beaufort, N. C. and Adjacent Regions, Bulletin of the Bureau of Fisheries XXXVI, Document No. 886. Washington, 1920.

Johnson and York,[7] and Johnson and Skutch[8] make certain winter references. But none of these works has completely described the winter conditions of the northwestern Atlantic.

There are a number of articles describing winter conditions in parts of the north and northeastern Atlantic. A comparison between the conditions described in these works and the winter conditions observed in Halifax makes a very interesting study. A few of the publications that suggested comparisons, should be mentioned. Kjellman[9] in "The Algae of the Arctic Sea" records seasonal observations in the ecological discussion of the plants of that region. For the British Isles, A. D. Cotton[10] has described the seasons in Claire Island from Febuary to October, and Knight and Parke[11] have recently published a very full account of the Manx algae, including information for all seasons. These comprehensive articles proved most interesting in comparison with conditions here, both in points of similarity and in points of dissimilarity. Many of the latter are mentioned in the notes referring to the various species.

The sub-littoral vegetation of an exposed coast is always difficult of exploration, and winter collecting even in the shelter of such a harbour as Halifax (See Figure I) is in most places not only difficult but dangerous. The ice and slipperiness of the rocks, together with the wind and cold turbulent water, make careful collecting impossible for most parts of the harbour. Usually it is necessary to depend on material washed up on the shore. But when these regular winter observations were started at Halifax, it was found that continuous collecting of deep water forms could be carried on at the main outlet of

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[7] Johnson, D. S. and York, H. H. The Relation of Plants to Tide-Levels. Carnegie Institution of Washington, Publication No. 206, 1915.

[8] Johnson, D. S. and Skutch, A. F. Littoral Vegetation of the Headland of Mt. Desert Island, Maine. Parts I, II & III. Ecology IX, 188-215; 307-338; 429-448. 1928.

[9] Kjellman, F. R. The Algae of the Arctic Sea. Stockholm, 1885.

[10] Cotton, A. D. Claire Island Survey, Marine Algae, Part 15. Proceeding of the Royal Irish Academy XXXI, 1912.

[11] Knight, Margery and Parke, Mary W. Manx Algae. L. M. B. C. Memoirs, No. XXX. Liverpool. 1931.

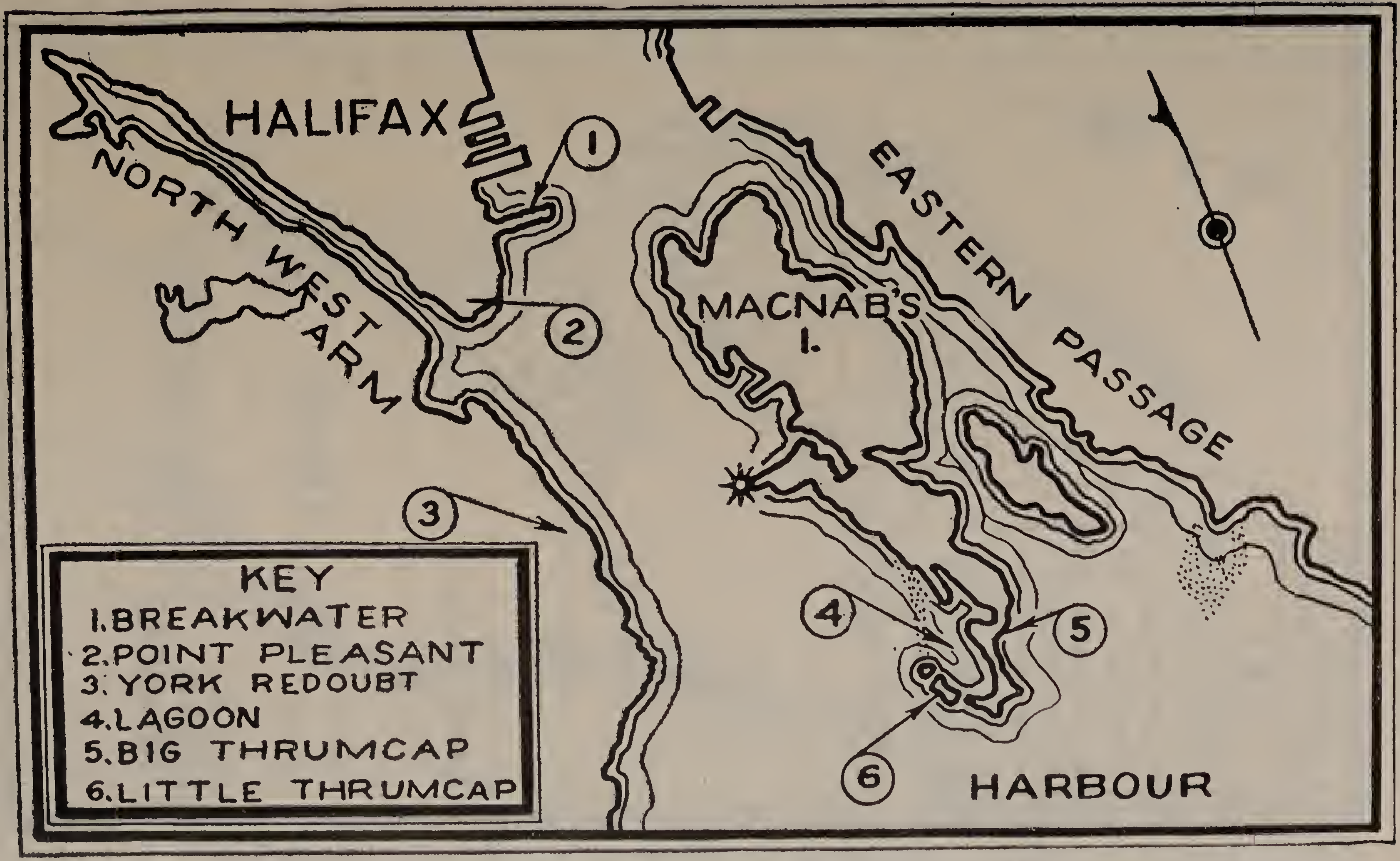

Fig. I. Map of Halifax Harbour Indicating the Principal Collecting Stations.

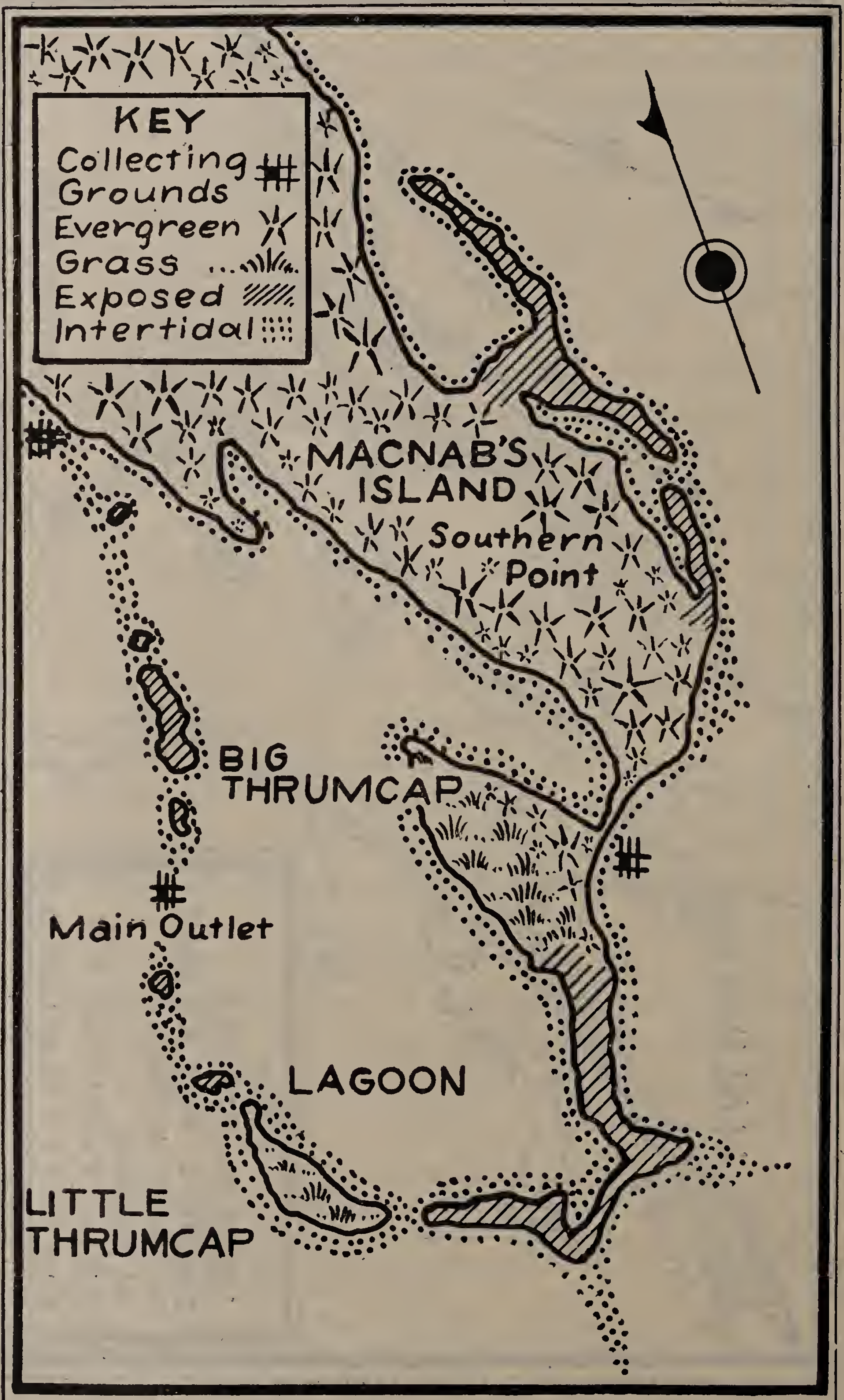

Fig. II. Map of Thrumcap Area.

the Thrumcap lagoon, (See Figure II) provided the collector was suitably equipped with waders and adequately protected against the cold. There are three of these exits, one of which becomes dry at low tide, one very nearly dry, but the third, the main outlet, is never completely dry even when the water is at its lowest. The depth at dead low tide varies from fifteen inches near the lagoon to ten inches in the shallower parts. The result is that semi-deep water conditions prevail. A current is always present, its direction depending on the ebb or flow of the tide and the relative level of the water in the lagoon. This current flows about 50 feet in 15 seconds. It exists throughout the entire length and breadth of the outlet which is about one hundred and fifty feet from the edge of the lagoon to the breakers at low water and about the same distance from side to side. The rocky bottom forms a good foothold for even the largest algae, and other conditions are evidently favourable, for, with the exception of forms to be obtained only by dredging or from the wash, practically all the deep water forms of the region occur here. The conditions that make continuous collecting possible are the lack of ice and the temporary freedom from surf during low tide. The water flows too rapidly for the formation of ice, assuring at all times a clear view of the bottom. For most of the day the outlet is covered by fairly deep water and a line of breakers. As the tide goes down the line of surf recedes sufficiently to allow the collector to wade out into the stream in perfect safety.

As compared with other situations the habitat of this outlet is typically marine and sub-littoral. The only important respects in which it differs from the sea are in the matter of light and temperature. The shallow unshaded water permits more light to reach the bottom than ever penetrates to the ocean floor, and as the water flows out from the lagoon it has a temperature slightly colder in winter and warmer in summer than the water at the mouth of the harbour. The place does not in any way resemble a tidepool. Stagnation never occurs, for the water is always moving; nor is the outlet subject to extremes of temperature, for water from the open sea flows in and out twice each day keeping the conditions about the same as those of the ocean. From the standpoint of the algologist this main outlet of the lagoon is an ideal winter collecting ground for sub-littoral marine forms and during the course of this present work it has been of unusual interest.

Along with the lagoon outlet and on the same dates, three other places at Thrumcap were examined, namely the southern barrier beach, the tide pool north of the lagoon, and the lagoon itself.

The barrier beach runs across the southeast end of the lagoon, from Little Thrumcap to MacNab's Island. It separates the lagoon from the ocean and includes the shore on the south side of Big Thrumcap. It was already familiar, having been visited many times every summer during the progress of the survey. This barrier includesa s mall crescent-shaped beach in which is trapped the wash from the long Thrumcap reef and from the shoals off Devil's Island. Great numbers of deep water forms are cast up here especially after storms.

The tide pool north of the lagoon also received minute inspection. It is about eighty-five yards long and twenty-seven yards wide and is a shallow pool typical of the upper littoral zone. The bottom is of small stones, pebbles and sand. Shortly after the tide starts to fall it becomes a completely isolated body of shallow water. It has no currents and remains undisturbed and unchanged for about nine hours until the tide comes into its level again. Hence this pool provides conditions that contrast sharply with those found in the outlet.

The lagoon is one mile long by half a mile wide. Its greatest depth is fifteen feet, and the bottom is of mud and stones. It is well protected on all sides, being enclosed by MacNab's Island on the east and north, Big and Little Thrumcaps and the barrier reef on the south, and the barrier reef with its outlets on the west. The surface is always comparatively calm and during the summer its water becomes warmer than that of the surrounding ocean. Although so well protected this lagoon cannot be looked upon as a big tidepool, for it is too deep and covers too large an area, and in addition the diurnal exchange of water between it and the ocean maintains a continuous and fairly rapid current at certain places. The presence of these currents is well demonstrated during the winter, for there are certain spots that never freeze even in the coldest weather. In this lagoon the turbulent water from an exposed part of the coast is taken in direct and given temporary shelter. In its flora the lagoon provides a very interesting combination of forms. It includes those that cannot live in bays but demand the unpolluted water fresh from the ocean itself as well as those that usually inhabit any sheltered body of water.

Between November 1930 and July 1932, twenty-one consecutive monthly visits were made to these collecting grounds in the Thrumcap area. Each visit included inspection of the outlet, beach, tidepool, and lagoon. In this manner four representative places were examined during two winters.

To obtain a comprehensive picture of the seasonal change for an area, it is necessary to make observations in all kinds of habitat. The other stations chosen for this investigation at Halifax include every type of shore from steep rugged rocks to sand or mud, and every type of exposure from the bleak shores of Devil's Island to the sheltered coves at the head of Bedford Basin. Visits were made to these places at all seasons though at less regular intervals than to Thrumcap. These stations showed certain differences from the cycle of growth seen at the lagoon outlet and gave much valuable comparative information. The more important of these collecting grounds are listed below.

Points Visited at All Seasons.

1. *York Redoubt.*

This station is on the west side of the harbour opposite to Thrumcap. It is an exposed situation barely inside the harbour mouth. The coast here is rugged and the rocks steep. The observations made at this point provided an excellent comparison for the deep water forms.

2. *Point Pleasant.*

This is a semi-exposed situation. The shore is of boulders. Extending out under the water is a long gently sloping shelf of rock and a long reef of rocks and mud. Many species of the Laminaria association form extensive beds on this reef, and at a very low tide it is possible to walk out among these plants.

3. *The breakwater of the ocean terminals.*

The breakwater is built of artificially placed blocks of stone laid down in the middle of the harbour. The sides are steep and rugged with many crevices. They provide much the same type of habitat as is found at York Redoubt, but in a semi-sheltered locality. In regard to exposure there is a wide range on the breakwater itself, for the south side is much more exposed than the north. The sides are so steep that on a clear calm day it is possible to stand on the lower rocks and observe the algal growth to its lower limits. A good foothold is provided by the blocks of rock, so that collecting can be done here during any kind of weather and at all seasons.

4. *Maugher's Beach.*

This is a barrier of rock and sand extending from the lighthouse to MacNab's Island. On the exposed south side it receives the wash from the reef known as Lighthouse Bank, and on the north side the wash from Horseshoe Shoal. The barrier provides two beaches suitable for collecting, each of which includes both sand and boulders.

Collecting Points Not Visited in Winter.

In addition to these four collecting stations which were examined both winter and summer there were other parts of the harbour where collections were made in all but the severest months of the winter. Chief among these were: the Northwest Arm, slightly warmer than the harbour in summer and possessing many wharves and other woodwork to which algae become attached; Bedford Basin, from which there are several coves and inlets; Devil's Island, just outside the mouth of the harbour, an exposed bleak island with steep rocky cliffs washed by spray, and possessing a small artificial anchorage with woodwork; Barrie's Reef, a long spit of sand running out from the shore opposite Devil's Island; and the Hen and Chickens, a reef of large boulders outside the mouth of the Northwest Arm. Dredging was carried on in the Northwest Arm, in the harbour off Lighthouse Bank, Middleground Shoal, Point Pleasant Shoal, Bedford Basin, and other places.

METHODS OF EXAMINATION OF MATERIAL.

Due to the proximity of the collecting grounds to Dalhousie University, it was possible to bring the material collected to the botanical laboratories for examination on the same day. Many specimens were killed and fixed or otherwise preserved in the field. Some were later imbedded in paraffin and sectioned for detailed study. Still others were brought living to the laboratory and either mounted or examined microscopically for fruiting stages, etc. In this way it was possible to mount and examine fresh living specimens.

INFORMATION GATHERED AND CONCLUSIONS REACHED AS A RESULT OF THIS INVESTIGATION.

Species List.

The following is a list of the species found at Halifax. Those that were included in the marine flora at the main outlet of the lagoon are marked by an asterisk.

CHLOROPHYCEAE.

Bryopsis plumosa, Ag.
**Chaetomorpha aerea*, (Dillw.) Kuetz., forma *Linum*, (Muell.) Collins.
Chaetomorpha melagonium, (Web. & Mohr.) Kuetz., forma *typica*, Kjellm.
**Cladophora crystallina*, Kuetz.
**Cladophora flexuosa*, (Griff.) Harv.
Cladophora flexuosa, (Griff.) Harv., forma *densa*, Collins.
Cladophora gracilis, (Griff.) Kuetz.
Cladophora hirta, Kuetz.
Codiolum pusillum, (Lyngb.) Kjellm.
Enteromorpha compressa, (L.) Grev.

**Enteromorpha intestinalis*, (L.) Link, forma *clavata*, J. Ag.
Enteromorpha intestinalis, (L.) Link, forma *cylindracea*, J. Ag.
**Enteromorpha Linza*, (L.) J. Ag.
Enteromorpha minima, Naeg., forma *glacialis*, Kjellm.
Enteromorpha prolifera, (Muell.) J. Ag.
**Hormiscia penicilliformis*, (Roth) Fries.
**Monostroma fuscum*, (Post. & Rupr.) Wittr.
**Rhizoclonium tortuosum*, Kuetz.
Rhizoclonium tortuosum, Kuetz., forma *polyrhizum*, Holden.
**Spongormorpha arcta*, (Dillw.) Kuetz.

PHAEOPHYCEAE.

Agarum Turneri, Post. & Rupr.
**Alaria esculenta*, (L.) Grev.
Ascophyllum Mackaii, (Turn.) Holmes & Batters.
**Ascophyllum nodosum*. (L.) Le Jolis.
Asperococcus echinatus, (Mert.) Grev.
Castagnea virescens, (Carm.) Thuret.
Castagnea Zosterae, (Mohr.) Thuret.
**Chorda Filum*, (L.) Stackh.
**Chordaria flagelliformis*, (Muell.) J. Ag.
Desmarestia aculeata, (L.) Lamour.
**Desmarestia viridis*, (Muell.) Lamour.
Desmotrichum undulatum, (J. Ag.) Reinke.
**Dictyosiphon foeniculaceus*, (Huds.) Grev.
**Ectocarpus confervoides*, (Roth) Le Jolis.
**Elachistea fucicola*, (Vell.) Fries.
**Fucus evanescens*, Ag.
Fucus platycarpus, Thuret.
**Fucus vesiculosus*, L.
Fucus vesiculosus, L., variety *sphaerocarpus*, Farlow.
**Ilea fascia*, (Muell.) Fries.
**Ilea zosterifolia*, (Reinke) S. & G.
**Laminaria Agardhii*, Kjellm.
**Laminaria digitata*, Lamour.
Laminaria longicruris, De la Pyl.
Mesogloia divaricata, (Ag.) Kuetz.
Punctaria latifolia, Grev.
**Punctaria plantaginea*, (Roth) Grev.
**Pylaiella littoralis*, (L.) Kjellm.
**Ralfsia verrucosa*, Aresch.
**Saccorhiza dermatodea*, (De la Pyl.) J. Ag.
**Scytosiphon lomentarius*, (Lyngb.) J. Ag.

RHODOPHYCEAE.

Ahnfeltia plicata, (Huds.) Fries.
Antithamnion cruciatum, (Ag.) Naeg.
Antithamnion floccosum, (Muell.) Kleen.
**Bangia fusco-purpurea*, (Dillw.) Lyngb.
Callithamnion Baileyi, Harv.
Callithamnion corymbosum, (Sm.) Lyngb.
**Ceramium rubrum*, (Huds.) Ag.
**Chondrus crispus*, (L.) Stackh.
**Corallina officinalis*, L.

Cystoclonium purpurascens, (Huds.) Kuetz.
Delesseria alata, Lamour.
Delesseria sinuosa, (Good. & Woodw.) Lamour.
**Dumontia filiformis*, (Muell.) Grev.
Gigartina mamillosa, (Good. & Woodw.) J. Ag.
**Gloiosiphonia capillaris*, (Huds.) Carm.
Halosaccion ramentaceum, (L.) J. Ag.
* *Hildenbrandtia rosea*, Kuetz.
**Lithothamnion* spp.
Melobesia LeJolisii, Rosan.
Nemalion multifidum, (W. & M.) J. Ag.
**Petrocelis cruenta*, J. Ag.
Polyides rotundus, (Gmel.) Grev.
**Polysiphonia fastigiata*, (Roth) Grev.
**Polysiphonia nigrescens*, (Dillw.) Grev.
Polysiphonia Olneyi, Harv.
**Polysiphonia urceolata*, (Lightf.) Grev.
**Polysiphonia violacea*, (Roth) Grev.
**Porphyra laciniata*, (Lightf.) Ag.
Ptilota pectinata, (Gunn.) Kjellm.
Rhodochorton Rothii, (Turt.) Naeg.
**Rhodomela subfusca*, Ag.
**Rhodymenia palmata*, (L.) Grev.

Forms Peculiar to Winter Alone.

As regards the search for forms that occur in winter alone, no exclusively winter forms were found. Even those algae which have their most abundant crops in the winter months can be found at some time between May and October. If this feature, common to all the forms of marine algae in Halifax Harbour, is characteristic for other parts of the Maritime Provinces as well, it is unlikely that the difficulties of winter collecting caused any serious omissions from the list of algae for these provinces.

Succession of Algal Crops.

The sea is never wholly without active vegetation. The dormant period common to land plants is entirely lacking, and during the winter some of the marine algae are at the height of their season. From another standpoint, that of crop succession, marine and land flora are very similar, for in each environment the crop of one season is regularly replaced by that of the next. But even in this there is a difference. In the ocean the succession of crops goes on for twelve months of the year. There is a general sweeping away of large forms in the autumn, but even while this is going on the perennials continue their growth, and other forms are beginning their development. There is no intervening period of inactivity so common to the land flora of this climate. In describing this circle of development perhaps the most logical starting point is the time when the growth of marine forms is at its lowest. At Halifax this is in the early autumn. The sequence of species is described as it occurs in the main outlet of the Thrumcap lagoon. Instances in which other places at Halifax differ from this sequence are cited elsewhere.

September and October Season.

September and October are the poorest months of the year for algal growth and mark the end of the summer "season". The annuals have been gradually washing in during the late summer and the remaining ones now submit to the wholesale destruction caused by the early autumn storms. Even the ever present perennials look old and worn. *Chondrus* is covered with shellfish and many species have grown so large during the comparatively calm months of the summer that, when the autumn storms come on, they are torn from the rocks. Certain forms are always left, including *Ascophyllum nodosum*, species of *Fucus*, *Enteromorpha*, *Polysiphonia*, a few scattered clumps of the nomadic *Ilea fascia*, etc. Beds of *Chondrus crispus* cover a large part of the bottom and grow around the base of nearly every rock. But many of these algae are comparatively small whereas most of the conspicuous species become washed away about the end of August. The final stage in the disappearance of the plentiful summer growth takes place during a very few weeks with the result that the shore has a more barren appearance at this time than at any other season.

November to the Middle of January Season.

November sees the beginning of a new crop which consists chiefly of filamentous Reds. These establish themselves so vigorously and in so many places over the bottom that the bright red tufts of these young Rhodophyceae make beautiful patches of colour in the otherwise almost barren area. Certain of these plants are destined to remain and continue growth for nearly twelve months. These are *Polysiphonia urceolata*, *P. violaceae*, *Rhodomela subfusca* and *Ceramium rubrum*. There are other Reds which start their growth at this time but which do not continue to flourish for such a long period. Such a plant is *Dumontia filiformis* which usually appears about the end of December or the first of January. Starting at the same time as thee filamntous Reds are two Browns, *Ilea fascia* and *Scytosiphon lomentarius*. In among these forms, young plants of *Laminaria Agardhii* may be seen as early as the middle of November. All these forms of both Reds and Browns grow very rapidly during November, until by the middle of December the bottom and all the projecting rocks are covered with large plants of these species. By January certain of these plants show signs of age. The long and large *Scytosiphon* plants become reddish brown and many are washed away. The *Ilea* becomes white on the edges or dark brown all over. In either case it begins to disintegrate and break off. Some of the filamentous Reds become brown with diatom epiphytes. Even until the middle of January, however, the dominant forms are filamentous Reds and large beds of *Scytosiphon* and *Ilea*.

Middle of January to April Season.

During December and early in January, small plants of certain Greens can be observed. These are chiefly *Monostroma fuscum*, *Hormiscia penicilliformis*, *Spongomorpha arcta*, and *Enteromorpha Linza*. By the middle of January they are conspicuous and by February they have grown to such an extent that the whole aspect of the flora changes suddenly to a bright green. The only exceptions to this green colour are extensive beds of *Dumontia* and the tops of certain larger rocks that have during the same period become covered with a dense growth of *Bangia fuscopurpurea*. But in spite of the *Bangia* and the *Dumontia* the whole growth has a green appearance.

The species that contributes the greatest surface of green is *Monostroma fuscum.* It grows epiphytically on *Chondrus crispus*, and is so plentiful that it is almost impossible to find a *Chondrus* plant uninfected. In among these green plants may be found two newcomers, small plants of *Alaria esculenta* and *Chorda Filum.* The latter appears first about the middle of March. *Laminaria Agardhii* continues to lengthen and assumes its typical frilled appearance. *Scytosiphon* to a considerable extent and *Ilea* to a less extent are still present though in a disintegrating condition. *Dumontia* becomes long and twisted and is a dark purple-red in colour. But the Greens are so numerous and extensive that their colour continues to dominate the region all through February and most of March. This green phase ends abruptly. By about the end of March, the *Monostroma* plants disintegrate and are completely washed away as a fine green scum. The *Enteromorpha Linza* turns white and breaks off. The *Hormiscia* disappears from the rocks where it was first found. The only Green that remains in any quantity is *Spongomorpha arcta* which becomes stringy and much less conspicuous. The *Bangia* dies, remaining on the tops of the rocks as a greyish brown covering of decaying filaments. The conspicuous growth of the green period is at an end.

April to the End of August Season.

As a result of the disintegration of the Greens, the general colour of the flora suddenly becomes brown. This colour is not due to the *Phaeophyceae* so abundant in early winter. The *Ilea* has almost disappeared. *Scytosiphon* is present but not conspicuous. The *Dumontia* is still plentiful but not conspicuous. The conspicuous plants are large, including *Chorda Filum, Laminaria Agardhii, Alaria esculenta*, and *Saccorhiza rjatodea.* Under cover of the growth of the previous months these plants have grown extensively and with the disappearance of the Greens they can be seen everywhere. *Polysiphonia* and *Rhodomela* are also much longer and most of them are also brown due to epiphytic diatoms. For a few weeks these species have undisputed possession of the area, but on all the rocks there may be found small plants that at first look like a fine species of *Dictyosiphon*, but which on examination prove to be young plants of *Chordaria flagelliformis*. From then on, that is from about the first of May until the middle of July, *Chordaria* gradually becomes more and more prevalent providing an excellent example of one species replacing nearly all others. *Laminaria Agardhii* and *Alaria esculenta* become broken off in the current. The dark brown hairs on the *Chorda Filum* become bleached and finally whole plants are washed away. The *Scytosiphon* that remains becomes infected with *Dictyosiphon foeniculaceus*, and later both host and epiphyte are washed away. The *Dumontia* plants disintegrate and gradually disappear. The filamentous Reds remain, but are now very brown with diatoms. But the *Chordaria* continues to flourish and by the middle of July everything is covered with the long heavy dark plants. The end of this phase starts about the end of July with the ageing of the *Chordaria*. This species remains the dominant form all through August and up to the time when all the remaining annuals are swept away by the autumn storms. This brings the account of the cycle of growth back to the starting point.

The sequence of crops throughout the year in the lagoon is well illustrated by the following table:

September & October.		Barren season, perennials only.
November to middle of January.	early	Development of filamentous Reds, *Dumontia*, *Ilea*, *Scytosiphon* and young Laminarias.
	late	*Ilea* mature. *Scytosiphon* large.
Middle of January to April.	early	Start of Greens. Young *Alaria*. Predominance of Greens.
	middle	Continued growth of Laminarias and *Dumontia*. Start of *Chorda*. Start of *Chordaria*.
	late	Disintegration of Greens.
April to end of August.	early	Predominance of *Chorda*, *Laminaria*, etc. and predominance of browned filamentous Reds.

	Increase of *Chordaria*. Decay of Browns other than *Chordaria*.
middle	Predominance of *Chordaria*. Decay of nearly all the annuals.
late	Washing away of nearly all the annuals.

The seasonal description outlined above follows the main course of succession in the lagoon outlet, but it is not entirely applicable to the whole region. By itself it would be misleading. Certain forms which almost disappear from the outlet during the summer are found growing in large quantities at some other level. Filamentous Reds which may grow old in the outlet as early as March are washed up in a healthy condition from deeper waters much later in the season. For a complete picture of the sequence of crops of marine algae around Halifax, the outlet has certain deficiencies. The deficiencies were made up by observations at other suitable collecting stations. The additional information gained by the observations at these other places is dealt with, in part, in the comparative description of these stations, and in part, in the notes regarding each species.

Comparison of the Principal Collecting Stations.

Other Stations in the Thrumcap Area.

Each of the other three collecting places at Thrumcap differ from the outlet in several respects, all of which are due to the individual nature of the various habitats. The way in which each of the other three stations at Thrumcap supplemented the information obtained at the outlet will be stated briefly for each place.

The Barrier Beach at the south end of the lagoon yields additional deep water forms which do not grow in the outlet. *Agarum Turneri* is cast up in great quantities. *Ahnfeltia plicata* and occasional rare Reds can often be collected. All the deep water forms on the beach are large in size and total number. Also the collections on the beach provide very valuable corroborative evidence. When young *Laminaria*, *Alaria*, *Saccorhiza*, *Polysiphonia*, *Rhodomela*, etc. were observed in the outlet, the species was very often absent from the wash on the beach, but when the plants in the outlet grew larger, plants of a similar size appeared in the wash. This indicated that the outlet represents correctly the conditions that exist in the deeper water.

THE SHALLOW TIDEPOOL at the north end of the lagoon supplied information typical of the upper part of the littoral zone. The growth was more transient and the plants matured faster than in the outlet. Although *Ilea*, *Scytosiphon*, *Dumontia*, *Monostroma*, and other forms not requiring deep water are common to both places, the seasonal progress is quite different and many species are entirely lacking. *Ilea*, *Scytosiphon*, and *Dumontia* appear later and disappear earlier in the pool, practically filling its lower end before becoming well advanced in the outlet. Toward late spring everything disintegrates and is washed away leaving only a few soft and unhealthy specimens. This is typical for most of the higher portions of the littoral zone.

THE LAGOON is a fairly large body of water. It contains a much greater variety of forms and many of the plants are larger than those in the outlet. Frequently a species was scarce in the outlet and escaped observation, but when the lagoon was examined this species was found; on subsequent closer examination the outlet was observed to contain it also. In respect to certain forms the lagoon is intermediate in growth between the pool and the outlet. In addition it has many forms not found in either of the other two places. *Bryopsis plumosa*, *Castagnea Zosterae*, *Mesogloia divaricata*, and other species are very abundant here but never in the outlet or pool. *Melobesia LeJolisii* occurs in both lagoon and pool but never in the outlet for no *Zostera* is found there. Large plants of *Desmarestia viridis* grow abundantly in the lagoon, but only once has it been found in the outlet. Other instances could be cited but these are sufficient to indicate the way in which examination of the more extensive growth of the lagoon checked and supplemented the observations made at the outlet.

Stations Outside the Thrumcap Area.

The more important ways in which the succession of marine algal crops in other parts of the harbour vary from that of the outlet are as follows. In general the autumn débâcle was later at York Redoubt on the west side of the harbour than on the east side at Thrumcap. This may be associated with the fact that the prevailing winds at this time of year are from the northwest. The west side of the harbour is sheltered from these by high cliffs. As autumn approaches most annuals become bleached, but on the western side of the harbour, the annuals, both Browns and filamentous Reds, retain their colour for a longer period. This again may be associated with the shade provided by the cliffs. In the North West Arm and at the head of Bedford Basin, the season for many Browns and Reds comes to an end early in the summer. Most of the species of the Phaeophyceae and the Rhodophyceae become infected with *Ectocarpus* early in July, and in turn the *Ectocarpus* becomes infected with diatoms. The season for the Greens in these two places is exactly the reverse of that in the lagoon outlet. Species of *Enteromorpha*, *Cladophora*, *Chaetomorpha*, and *Phizoclonium* abount in both the North West Arm and at the head of Bedford Basin during July and August. In both places the woodwork becomes covered with various species of *Enteromorpha*. *Ectocarpus* and *Porphyra* usually accompany these Greens, but as already stated the *Ectocarpus* becomes infected with diatoms about August. The same quiet waters provide certain species that are rarely found elsewhere, such as *Laminaria longicruris* and also certain ecological freaks like inflated cylindrical bleached plants of *Dumontia filiformis*. There are shallow bays off Bedford Basin, of which Wright's Cove is the best example. These have a considerable tidal current that may become quite warm. The growth in these places is very rich. It matures early and is largely washed away by the middle of August. On the Breakwater and at places like Devil's Island and York Redoubt, luxuriant growths of *Laminaria*, especially

L. Agardhii, may be found at all seasons of the year. During the fortunate combination of a calm sea and a very low tide it was possible to examine the surf beaten bed of *Polysiphonia violaceae* on the Hen and Chickens Shoal. This was in August, and the plants were growing luxuriantly and in a healthy condition. At Devil's Island plants of *Chondrus crispus* could be seen forming extensive beds over surf beaten rocks, showing that the species is really plentiful on this coast, but on account of the exposed localities in which it grows it is not always observed even in places where it is abundant. To use the succession of crops at the main outlet as a guide and to compare the other places with it, as has been done here, is the best way to arrive at a picture of the normal or average succession for the region.

TABULATED ACCOUNT OF SPECIES COLLECTED IN THE HARBOUR DURING THE SURVEY.

CHLOROPHYCEAE.

Bryopsis plumosa

Frequency: rare.
Collected in Thrumcap lagoon only.
Habitat: on stones in shallow water.
Season: July and August.

**Chaetomorpha aerea, forma Linum*

Frequency: common.
Collected in lagoon outlet, Lagoon, North West Arm, and Wright's Cove.
Habitat: floating in warm shallow water.
Season: summer.

Chaetomorpha melagonium, forma typica

Frequency: common.
Collected in Wright's Cove.
Habitat: sub littoral.
Season: summer.
Note: unattached masses floating near sandy bottom of cove among vascular plants. Frequently infested with epiphytes such as many small shellfish.

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*Algae observed in lagoon outlet.

Cladophora

Species of this genus are said by Collins to be in part annual—most of them perennial, dying down to the base and growing again the following year. Seasons given here are of actual collections.

*_Cladophora crystallina_
Frequency: occasional.
Collected in Thrumcap lagoon and outlet.
Habitat: attached to stones and Fucus about mid-tide and below.
Season: summer.

*_Cladophora flexuosa_
Frequency: common.
Collected in Wright's Cove, Lagoon, North West Arm, etc.
Habitat: near low water.
Season: summer.

Cladophora flexuosa, forma densa.
Frequency: occasional.
Collected in Wright's Cove.
Habitat: usually near low tide mark and in deep pools.
Season: summer.

Cladophora gracilis
Frequency: common.
Collected in pools inside wooden breakwater at Maugher's Beach Light.
Habitat: from mid to low tide.
Season: summer and early autumn.
Note: often found in mats lying on sand at low tide.

Cladophora hirta
Frequency: occasional.
Collected at Point Pleasant.
Habitat: semi-exposed situations.
Season: summer.

Codiolum pusillum
Frequency: occasional.
Collected on the breakwater.
Habitat: on rocks below high tide level.

Season: spring.

Note: forms a mossy coating on rocks at end of breakwater. Undoubtedly in other similar situations.

Enteromorpha

Enteromorphas are found throughout the year but their largest crop is in Spring and summer. Along with *Monostroma* and *Hormiscia*, *Enteromorpha Linza* they form a constituent of the green season.

Enteromorpha compressa

Frequency: abundant.

Collected in North West Arm.

Habitat: woodwork.

Season: all seasons, most abundant in summer.

**Enteromorpha intestinalis forma clavata*

Frequency: abundant.

Collected in North West Arm, lagoon outlet, etc.

Habitat: woodwork and stones.

Season: summer.

Enteromorpha intestinalis forma cylindracea

Frequency: common.

Collected in Wright's Cove, Thrumcap lagoon, North West Arm.

Habitat: usually unattached.

Season: summer.

Note: *Enteromorpha intestinalis* usually occurs in quiet parts of the harbour.

**Enteromorpha Linza*

Frequency: abundant.

Collected in North West Arm, breakwater, lagoon outlet, etc.

Habitat: on stones, woodwork, etc.

Season: spring and summer and other seasons.

Note: of all the algae at Halifax this species is the most widely distributed. It is found at all seasons and in a wide variety of habitat.

Enteromorpha minima, forma glacialis

Frequency: common.

Collected at the breakwater, in the North West Arm, etc.

Habitat: on stones, woodwork, ironwork, etc. in upper littoral zone.

Season: all seasons, most abundant in summer.

Note: forms extensive green felt-like covering over sloping surfaces, completely covered only at high tide. At other times may be washed with spray.

Enteromorpha prolifera

Frequency: common.

Collected in North West Arm and Bedford Basin.

Habitat: in sheltered places, near low water mark.

Season: summer.

* *Hormiscia penicilliformis*

Frequency: common.

Collected at Point Pleasant, Thrumcap, York Redoubt, etc.

Habitat: chiefly on boulders between tide marks.

Season: winter and early spring becoming confined to limited areas in summer.

Note: Found on rocks in exposed situations, preferring smooth rounded boulders to more rugged rocks. Abundant from January to April. Occurs suddenly in winter at and slightly above the high water line along with *Bangia* and a small amount of the narrow *Porphyra.* With the advance of spring the growth proceeds down the shore leaving the upper rocks bare. Towards summer it becomes less abundant and by midsummer confines itself to small bay-like indentations in the boulder beaches, where it can be found in small quantities near low water.

**Monostroma fuscum*

Frequency: abundant.

Collected throughout the harbour.

Habitat: on stones and woodwork, and epiphytic on Chondrus, etc. in outlet and at Point Pleasant.

Season: late winter and early spring. Small quantities at other seasons.

Note: Deep green glossy plants. Chief constituent of green season.

**Rhizoclonium tortuosum*

Frequency: fairly common.

Collected in Thrumcap lagoon, tidepools at Point Pleasant and Wright's Cove.

Habitat: in sheltered places.

Season: spring, summer, and other seasons.

Note: It is noticeable by its dark green colour and habit of growing in twisted skeins or masses. Often found entangled in the cleft fronds of *Chondrus crispus* and the byssus threads of mussels, etc. Not of such general occurrence or abundance as most of the other greens.

**Spongomorpha arcta*

Frequency: abundant.

Collected in lagoon outlet, on breakwater, North West Arm and other stations.

Habitat: on rocks, woodwork and other algae from mid-littoral zone to low water and below.

Season: all seasons—most abundant in Spring.

Note: This form is found in varying quantities throughout the year. Plants are noticeably increased in size and numbers in February. Fruiting begins about March. In April the plants are very abundant.

PHAEOPHYCEAE.

Agarum Turneri

Frequency: abundant.

Collected in wash on Devil's Island, Thrumcap barrier beach, etc.

Habitat: in deep water.

Season: all seasons—washed up most abundantly in autumn and winter.

Note: At no point in Halifax Harbour has this form been observed attached as it so frequently is seen in the Bay of Fundy. Large amounts are washed in at Thrumcap, the winter wash often consisting entirely of great numbers of these plants.

**Alaria esculenta*

Frequency: abundant.

Collected at Devil's Island, York Redoubt, Point Pleasant lagoon outlet, and barrier beaches, etc.

Habitat: in exposed situations on rocks and woodwork at and below low water mark.

Season: all seasons.

Note: The special reproductive branches occur on all but very young plants, but fruiting occurs chiefly from June to September. Plants on the wooden breakwater at Devil's Island are very large. At York Redoubt they occur in great abundance but the upper plants of the association are very small. In the outlet the plant is an annual. On the beach young plants appear in the spring, older plants during the summer, very old plants in the autumn, and practically none during the early winter. This would suggest that the plants on the Thrumcap reef are also annuals. At York Redoubt the smaller plants are found throughout the year. The conclusion reached for *Laminaria Agardhii* apply also to this species.

Ascophyllum Mackaii

Frequency: common.

Collected in Wright's Cove, North West Arm, and Thrumcap lagoon.

Habitat: on stones at high water in warm sheltered waters.

Season: all seasons, perennial.

**Ascophyllum nodosum*

Frequency: abundant.

Collected throughout the harbour.

Habitat: on rocks and stones throughout the littoral zone.

Seasons: all seasons, perennial.

Note: Fruits chiefly in May. Unusually large plants in Wright's Cove.

Asperococcus echinatus

Frequency: common on Devil's Island.

Collected at Devil's Island.

Habitat: on rocks in lower littoral zone, and an atypical form on rocks near high water exposed to spray at low tide.

Season: spring and summer.

Note: No winter collections were made at Devil's Island.

Castagnea virescens

Frequency: not common.

Collected in Wright's Cove.

Habitat: in pools and sheltered situations.

Season: summer.

Castagnea Zosterae

Frequency: locally abundant.

Collected in lagoon.

Habitat: on Zostera.

Season: summer.

Note: Unusually large quantities on eel grass in lagoon at end of June 1931. Completely disappeared by end of July. In 1932 this species was entirely absent. The Zostera was late in appearing this year.

**Chorda Filum*

Frequency: abundant.

Collected in all parts of the harbour.

Habitat: on rocks and stones at and below low water.

Season: March to August, disappearing completely in early autumn.

Note: This species is listed by Knight and Parke as a pseudo-perennial on the Isle of Man. In Halifax it is annual in occurrence. Decaying specimens can be found as late as October in undisturbed situations such as at the head of the North West Arm but these are merely dead plants that have not yet been washed away.

**Chordaria flagelliformis*

Frequency: abundant.

Collected at all places in the harbour.

Habitat: Rocks, stones and woodwork at low water mark and below Higher levels in tide pools.

Season: summer.

Note: This species is the chief element of the "brown season". In late summer it frequently becomes infected with *Dictyosiphon foeniculaceus.* On the Isle of Man it occurs from the beginning of July to the end of November. In Halifax it appears first in March and by the end of August its season is definitely over. Some plants may persist even as late as December but most of it disappears during the autumn storms.

Desmarestia aculeata

Frequency: occasional.

Collected in wash on barrier beach.

Habitat: in deep water.

Note: Found washed up chiefly in summer.

**Desmarestia viridis*

Frequency: abundant.

Collected in Lagoon, lagoon outlet, North West Arm, and in wash on beaches.

Habitat: sublittoral on stones.

Note: Large plants seen growing in Lagoon and at mouth of North West Arm. One plant only in lagoon outlet. Washed in from reefs in large amounts to Thrumcap, Point Pleasant, and other beaches.

Desmotrichum undulatum

Frequency: occasional.

Collected at Thrumcap lagoon, Maugher's beach, and mouth of North West Arm.

Habitat: attached to *Chorda* and other algae and to *Zostera marina.*

Season: summer.

**Dictyosiphon foeniculaceus*

Frequency: very common.

Collected in all parts of Halifax Harbour.

Habitat: on rocks, small stones and other algae throughout the littoral zone.

Season: summer.

Note: Found in a variety of situations—rocky to muddy, often in pools. Usually epiphytic on *Scytosiphon* and *Chordaria*, particularly when the latter are beginning to age.

**Ectocarpus confervoides*

Frequency: abundant.

Collected in all parts of the area.

Habitat: rocks, woodwork, and other algae in lower littoral zone.

Season: spring and summer. Occasionally at other seasons.

Note: Often found with *Pylaiella*. Becomes covered with diatoms in summer. Other species are undoubtedly present in this area.

**Elachistea fucicola*

Frequency: common.

Collected at all points in the harbour.

Habitat: on *Ascophyllum* and *Fucus*.

Season: all seasons—most abundant in summer.

**Fucus evanescens*

Frequency: abundant.

Collected at Point Pleasant, York Redoubt, breakwater, lagoon outlet, North West Arm, Bedford Basin, etc.

Habitat: on rocks about mid-tide level.

Season: perennial.

Note: Grows at a slightly lower level than *Fucus vesiculosus* and is therefore more abundant in the lagoon outlet. Fruiting is most abundant in winter and very early spring.

Fucus platycarpus

Frequency: abundant.

Collected at all points in the area.

Habitat: on rocks in upper littoral zone.

Season: perennial.

Note: Found at a slightly higher level than *Fucus evanescens* and *Fucus vesiculosus*, but intertidal zone in this region is so narrow that overlapping occurs everywhere. Fruiting is most general from spring to autumn.

**Fucus vesiculosus*

Frequency: abundant.
Collected throughout the harbour.
Habitat: On rocks and stones between high and mid tide.
Season: perennial.
Note: In the lagoon outlet this species is less frequent than *Fucus evanescens* which grows at a slightly lower level. Fruits at all seasons, most copiously in spring.

Fucus vesiculosus, variety *sphaerocarpus*

Frequency: occasional.
Collected throughout the area.
Habitat; same as type.
Season: perennial.

**Ilea fascia*

Frequency: abundant.
Collected throughout the area.
Habitat: on rocks, stones and woodwork throughout the littoral zone and below.
Season: at all seasons, most easily collected in autumn and winter.
Note: A nomadic species, in great quantities in autumn at the level of dead low tide and slightly below, advancing up the shore during the late fall and winter, to recede again in spring. Remaining in summer in the littoral zone only in isolated patches but abundant near low water mark in certain exposed localities, where it is associated with *Enteromorpha Linza*.

**Ilea zosterifolia*

Frequency: occasional.
Collected in lagoon outlet, North West Arm, York Redoubt and elsewhere.
Habitat: on rocks, stones, and woodwork in littoral zone.
Season: all seasons.

**Laminaria Agardhii.*

Frequency: abundant.

Collected in all exposed and semi-exposed situations.

Habitat: on rocks below low tide mark.

Season: at all seasons.

Note: These plants can be seen at all seasons growing in deep water and on places like the breakwater, but in the lagoon outlet they have, in common with other kelps, a very definite season. In the outlet they are gradually washed away during the summer and in the early fall any remaining ones are torn off. In November new plants appear in the outlet while at the same time there is a large wash of old fruiting plants on the beach During the winter the young ones in the outlet increase in number and size, and assume their undulated margin. In the deeper water of the exposed reefs, the new plants grow larger during the winter. This is evinced by the great number of young plants that appear in the wash by February. After the appearance of these young plants very few old ones are found in the wash. On the breakwater both old and young plants can be observed throughout the whole winter. Here to a greater extent than on the beach young and old growth are always intermixed. But there are never any very large or very old plants on the breakwater.

These observations have most striking inferences in regard to the life cycle of *Laminaria Agardhii.* In the outlet it is an annual that starts growing in November and persists for about nine months. The evidence from the beach would suggest the same cycle with a longer period of growth. The growth on the breakwater is found at all seasons but does not appear to include perennial plants. All this evidence would strongly suggest that *Laminaria Agardhii* so long considered a perennial is either but a pseudo-perennial which fruits extensively in the fall or an annual which may last almost the full twelve months.

**Laminaria digitata*

Frequency: abundant.

Collected on all exposed situations.

Habitat: on rocks below low tide.

Seasons: all seasons.

Note: On Devil's Island plants of this species are much larger than elsewhere in the harbour. In the lagoon outlet they are relatively small and less frequent than *Laminaria Agardhii*. Their time of occurrence in the outlet corresponds closely to that of *Laminaria Agardhii*.

Laminaria longicruris

Frequency: occasional.

Collected in Northwest Arm and on Thrumcap barrier beach.

Habitat: on rocks and stones in deep, quiet water.

Season: all seasons.

Note: Dredged in the North West Arm where it is fairly common. Washed up occasionally at Thrumcap and elsewhere. On the breakwater it is possible to observe plants of all graduations in shape and size between *Laminaria Agardhii* and *Laminaria longicruris*.

**Mesogloia divaricata*

Frequency: occasional.

Collected in the lagoon and in wash on sheltered side of Maugher's Beach.

Habitat: on stones near low water mark.

Season: summer.

Punctaria latifolia

Frequency: occasional.

Collected in the lagoon and in wash on sheltered side of Maugher's Beach.

Habitat: on stones near low water mark.

Season: summer.

Note: In lagoon occurs on slope near the edge and is not quite exposed at low tide. Grows also on ledges of reefs from where it is washed to sheltered (north) side of Maugher's beach. *Isactis* and *Rivularia* frequently found on it giving plants a spotted appearance. Occasionally washed up in large quantities.

**Punctaria plantaginea*

Frequency: occasional.

Collected in lagoon, lagoon outlet, and on exposed side of Maugher's Beach.

Habitat: on stones below low water.

Season: spring and summer.

Note: Occasionally washed up in large quantities on the South (exposed) side of Maugher's Beach. It is usually old plants that are washed up and these are laden with *Isactis* and *Rivularia* covering the surface, and with *Polysiphonia*, *Ectocarpus*, etc. at the ends.

**Pylaiella littoralis*

Frequency: abundant.

Collected throughout the area.

Habitat: on stones, woodwork and other algae in littoral zone.

Season: all seasons.

Note: Most abundant in spring and summer, becoming laden with diatoms in latter part of summer and largely washed away in autumn. Particularly luxuriant in the North West Arm on woodwork.

**Ralfsia verrucosa*

Frequency: common.

Collected at Devil's Island, York Redoubt, Point Pleasant.

Habitat: on rocks, stones and shells in pools and near high tide.

Season: perennial.

Note: Extensive growth on sloping rocks at Devil's Island near high water line and above. In outlet is very scarce. All rocks in outlet are well covered with water at high tide.

**Saccorhiza dermatodea*

Frequency: abundant.

Collected in all exposed and semi-exposed places.

Habitat: on rocks below low water.

Season: at all seasons.

Note: In outlet has about the same cycle of growth as *Laminaria Agardhii.* In summer becomes very tough and laden with epiphytes. Fruiting most abundant in autumn and winter.

**Scytosiphon lomentarius*

Frequency: abundant.

Collected throughout the area.

Habitat: on rocks and stones throughout the littoral zone and below.

Season: all seasons, chiefly autumn and winter.

Note: Is most abundant in the lagoon outlet and at Point Pleasant in autumn and winter. It occurs along with *Ilea* and to a large extent follows the progress of that species. But its migration is not so clearly defined, for small amounts can be found at all levels at all times. Aging plants bear large amounts of *Dictyosiphon* and other epiphytes.

RHODOPHYCEAE.

Ahnfeltia plicata

Frequency: common.

Collected on Thrumcap barrier beach and similar beaches.

Habitat: in deep water.

Season: perennial, washed up chiefly in summer and autumn.

Note: Collections are usually made from material cast up on the shore or dredged. At Point Pleasant it is possible to observe and make collections of attached living plants growing among the *Laminarias*, the large beds of which are exposed at extremely low tides.

Antithamnion cruciatum

Frequency: rare.

Collected in wash and dredged off Point Pleasant reef.

Habitat: in deep water. When found here it was usually attached to *Ptilota pectinata.*

Season: summer.

Antithamnion floccosum

Frequency: locally common.

Collected on Hen and Chickens reef and at York Redoubt.

Habitat: on rocks and mussels below low water mark.

Season: summer.

Note: This form usually grows among or beneath other filamentous red algae. When the habitat is once located, the plants are very noticeable because of their deep blood-red colour.

**Bangia fusco-purpurea*

Frequency: common.

Collected at boulder beaches at Point Pleasant and Thrumcap, and on exposed rocks in outlet and breakwater.

Habitat: on rocks and woodwork. Especially on exposed sides of intertidal rocks and just above high water.

Season: winter and early spring.

Note: Davis lists this as a spring and summer form for Woods Hole but in Halifax it is chiefly important in winter and spring. It is found only rarely in summer and during that season is never found on any surface that becomes dry when the water recedes. In winter and spring usually accompanying *Hormiscia.*

Callithamnion Baileyi

Frequency: rare.

Collected at York Redoubt.

Habitat: rocks below low water mark.

Season: summer and early autumn.

Note: Found mixed with *Callithamnion corymbosum* and *Polysiphonia Olneyi.*

Callithamnion corymbosum

Frequency: rare.

Collected at York Redoubt and breakwater.

Habitat: rocks below low water mark.

Season: summer and early autumn.

Note: See *Callithamnion Baileyi.*

**Ceramium rubrum*

Frequency: common.

Collected in all parts of the harbour.

Habitat: on stones and other algae from mid tide to deep water.

Season: at all seasons.

Note: Found fruiting at all seasons—most copiously in summer. Washed up in largest quantities in July and August. In the lagoon outlet its "season" of vigorous growth is over earlier than this. The basal parts in the outlet are perennial.

**Chondrus crispus*

Frequency: common.

Collected in lagoon outlet, lagoon, Point Pleasant, Wright's Cove, Devil's Island, York Redoubt, etc.

Habitat: mid tide to low water mark and below.

Season: perennial.

Note: Found generally throughout the harbour, most abundant on Devil's Island, in the lagoon outlet, and at Point Pleasant. Shape varies from wiry and bushy to broad and flat. Colour varies from deep fluorescent purplish red to a light green. Dark red and light green plants may grow side by side. Fluorescent ones are usually found in the shade. Large amounts of fruiting plants are washed up on the barrier beaches in late summer. Fruiting plants are also found in the lagoon outlet in winter, and in the spring the Chondrus here forms a substratum for the large crop of Monostroma. Nowhere in Halifax Harbour does Chondrus occur in the large thin broadly laminated form so typical of the tide pools in the Bay of Fundy. Nor is it found in such abundance or so free from epiphytic shellfish as on the coast of Prince Edward Island.

**Corallina officinalis*

Frequency: common.

Collected generally throughout the harbour.

Habitat: on rocks from mid-tide downwards.

Season: at all seasons (perennial).

Note: Common in deep pools and at low water mark and below.

Cystoclonium purpurascens

Frequency: common.

Collected in wash at Thrumcap and Maugher's Beaches.

Habitat: in deep water.

Note: Commonly found here only during summer when. it is cast upon the beaches. Cystocarpic material frequent

Delesseria alata

Frequency: rare.

Collected off Lighthouse Bank.

Habitat: in deep water.

Note: Dredged off Lighthouse Bank in August. One specimen only. Attached to *Ptilota pectinata*.

Delesseria sinuosa

Frequency: occasional.

Collected in wash and by dredging.

Habitat: deep water.

Season: perennial.

Note: Washed up most frequently in summer, occasionally at other times of the year. Frequently attached to holdfasts of *Laminaria*. Cystocarpic material observed occasionally in summer.

**Dumontia filiformis*

Frequency: common.

Collected in lagoon outlet, lagoon, and tide pools at Thrumcap and Point Pleasant.

Habitat: on stones near low water and below.

Season: December to June, scarce in summer.

Note: Knight and Parke list this species as a spring and early summer form for the Isle of Man. In Halifax it is a winter-spring form and corresponds more closely in seasonal distribution to that of the Maine tide pools as described by Roy M. Whelden. Cotton also reports it for Claire Island, Ireland, as occurring in rock pools at all times "except summer". A peculiar form is found in the still waters of the North West Arm on rocks below the low tide level. The plants are hollow, cylindrical and of a peculiar pale colour, only the fruiting spots showing the characteristic red colour. A few plants may persist later but in general the season for *Dumontia* is over in June, to be resumed again in December.

Gigartina mamillosa

Frequency: not common.

Collected in exposed situations only.

Habitat: in crevices of rocks.

Season: at all seasons (perennial).

Note: This species is less common for Halifax Harbour than for most places on the Atlantic Coast. Nowhere on this coast is it so abundant as in the Bay of Fundy.

**Gloiosiphonia capillaris*

Frequency: rare, spasmodic.

Collected in lagoon outlet only.

Habitat: on stones along with *Polysiphonia* and *Ceramium.*

Season: summer, disappearing in August.

Note: The lagoon outlet was the only place where this form was observed during the whole of the Maritime Provinces survey. In 1931 fruiting plants were very plentiful in the outlet, but in 1932 the form was surprisingly scarce. An even more spasmodic occurrence is reported by Cotton for Claire Island, Ireland. He found the plant in several spots in 1909 but none at all in 1910.

Halosaccion ramentaceum

Frequency: abundant.

Collected at York Redoubt, Devil's Island, and breakwater.

Habitat: Upper margin of the sub-littoral belt.

Season: perennial, often reduced to basal parts in autumn.

Note: Not found in lagoon outlet though often cast up on Thrumcap beach. Most abundant at York Redoubt, Devil's Island, and breakwater. Beginning of growing season is in fall, being somewhat earlier in exposed than in sheltered places. In winter and early spring the growth is so extensive that by itself it may form an association covering rocks just above the *Laminaria* zone. In exposed situations the plants are usually wiry and much branched. In the comparative shelter of the breakwater many of the plants lose their wiry appearance, the main axis and branches growing in length and becoming broad and inflated. In this condition the plants are soft and easily washed away. The inflated plants are more common at the breakwater than elsewhere and it is possibly due to this character that the plants in autumn are scarcer here than at York Reboub Tetrasporic plants have been collected as early as January.

* *Hildenbrandtia rosea*

Frequency: occasional.

Collected in Bedford Basin, Point Pleasant, and other parts of the harbour.

Habitat: often with *Petrocelis cruenta* covering otherwise bare stones in the littoral zone.

Season: all seasons (perennial).

Note: Frequent in pools.

**Lithothamnion spp.*

Frequency: common.

Collected in all parts of the harbour.

Habitat: on stones and shells throughout the littoral zone.

Season: all seasons (perennial).

Note: The quantity here is very small as compared with such points as Whitehead and other places on this coast.

Melobesia LeJolisii

Frequency: abundant.

Collected in the lagoon, Thrumcap tidepool, Eastern Passage, Wright's Cove, etc.

Habitat: on *Zostera marina.*

Season: summer.

Note: Abundant in 1930 and 1931. In 1932 none was found up to the beginning of August. This deficiency was inevitable owing to the late development of the Zostera in this season. Reported by Howe from Long Island in winter. The winter condition here has not been determined owing to the freezing of the lagoon and the bays where eelgrass was known to exist. In the tidepool the Zostera had largely died down by winter, the Melobesia being washed away with it.

Nemalion multifidum

Frequency: occasional.

Collected on breakwater, in outlet, Thrumcap barrier beach, etc.

Habitat: rocks exposed at low tide.

Season: various seasons. Sporadic.

Note: Knight and Parke list this form for the Isle of Man as a "summer annual" in pools. Cotton also describes it as a purely summer growth in Claire Island. Davis for Woods Hole found it growing in "summer and possibly at other seasons". In Halifax Harbour it is usually found without other algae in somewhat exposed situations, often on the sloping surfaces of rocks washed by the surf. It has been found in November and January as well as in the warmer months.

**Petrocelis cruenta*

Frequency: occasional.

Collected in Bedford Basin, Point Pleasant, and other places in the area.

Habitat: on stones in littoral zone.

Season: perennial.

Note: Found with *Hildenbrandtia rosea* on otherwise bare stones.

Polyides rotundus

Frequency: occasional.

Collected in wash at Barrie's Beach.

Habitat: deep water.

Note: During the late summer and early autumn this form is occasionally washed ashore in large quantities, but as a rule it is entirely absent from the wash.

**Polysiphonia fastigiata*

Frequency: common.

Collected generally throughout the harbour.

Habitat: on *Ascophyllum nodosum.*

Season: all seasons (perennial).

**Polysiphonia nigrescens*

Frequency: common.

Collected at lagoon outlet, Point Pleasant, Hen and Chickens, York Redoubt, and other places.

Habitat: on rocks and stones in lower littoral zone and below.

Season: all seasons.

Note: Listed by Davis as a spring and summer form for Woods Hole. Knight and Parke class it as a "perennial or pseudo-perennial". Farlow and Howe also regard it as perennial. In the lagoon outlet it can be observed during the whole year.

Polysiphonia Olneyi

Frequency: occasional.

Collected at York Redoubt and breakwater.

Habitat: rocks below low water.

Season: summer.

Note: Has been found only occasionally in late summer along with *Callithamnion Baileyi* and *Callithamnion corymbosum.*

**Polysiphonia urceolata*

Frequency: common.

Collected in all but extremely sheltered situations.

Habitat: rocks, stones, and woodwork, in lower littoral zone.

Season: all seasons.

Note: Reported for Woods Hole by Davis as common in spring "passing out of season in early summer". Knight and Parke list it as a pseudo-perennial. Howe records a sterile plant of *Polysiphonia urceolata formosa* as having been cast up on Long Island Sound in February 1914. In the North West Arm it has a bright red colour in spring but becomes brown with diatoms in summer. In the lagoon outlet it can be observed at all seasons, being very noticeable in late fall and winter.

**Polysiphonia violacea*

Frequency: common.

Collected in all exposed and semi-exposed situations.

Habitat: rocks and stones near low water mark and below.

Season: all seasons. Washed up in large quantities in summer.

Note: This species is also given as a summer form for Woods Hole but like *Polysiphonia negrescens*, *Polysiphonia urceolata* can be found here all during the year.

**Porphyra laciniata*

Frequency: abundant.

Collected everywhere in the area.

Habitat: On almost every kind of substratum (except other algae) in the littoral zone.

Season: all seasons.

Note: A wide-spread alga of the littoral zone. Fruiting plants can be found at all seasons and epiphytes are never found on its lubricous surface. The plants in this harbour are dark in colour and never attain the size or shape of the large plants of the Bay of Fundy.

In January young narrow plants were found abundantly covering the otherwise bare boulders at Thrumcap and Point Pleasant. These boulders are very much exposed and at low tide are entirely unprotected from the sun. The plants remained for a short time only, and are totally absent from this position in spring and summer.

Knight and Parke report a narrow form, *Porphyra liniaris*, which is "common in winter" on the Isle of Man and which "appears to be the winter form of *Prophyra umbilicalis*, Kutz., var. *laciniata*, J. Ag".

The narrow plants at Halifax were carefully examined and were found to be like *Porphyra laciniata* in all but shape. They were undoubtedly young and in all likelihood are the same as those described by Knight & Parke.

Ptilota pectinata

Frequency: occasional.

Collected in wash on all beaches.

Habitat: deep water often on holdfasts of larger algae.

Season: all seasons (perennial).

Note: Cystocarpic plants have been collected occasionally in summer and autumn.

Rhodochorton Rothii

Frequency: occasional.

Collected on the breakwater.

Habitat: on rocks between tide marks, forming a deep red mossy coating.

Seasons: all seasons.

Note: Cruciate tetraspores abundant from January to March. Plants in January are of a bright colour and are more easily detected at this season, when the rocks at that level are bare of larger forms. In summer, plants become mixed with sand, short *Ectocarpus*, and other small algae, and are obscured by the growth of *Enteromorpha*, *Polysiphonia*, and other species. Thus this species is very inconspicuous during the summer although it may be quite plentiful. It appears to prefer somewhat shaded positions and on the breakwater is abundant only on the sheltered side.

**Rhodomela subfusca*

Frequency: abundant.

Collected in all exposed and semi-xpeosed positions.

Habitat: on rocks from about half time to low tide and below.

Seasons: all seasons (perennial).

Note: This robust species is more persistent than the other filamentous Reds, (Polysiphonia, etc.) during the barren season but otherwise follows the same development as they. Fruiting occurs at all seasons, most abundantly in winter and spring.

**Rhodymenia palmata*

Frequency: common.

Collected at York Redoubt, breakwater, Point Pleasant, lagoon outlet, and washed upon beaches.

Habitat: on rocks and larger algae in lower littoral and sub-littoral zones.

Season: all seasons.

Note: In lower littoral zone it usually occurs on rocks protected from direct surf at low tide. In sub-littoral zone it often occurs along with *Laminaria* and other kelps, and is often washed ashore attached to their stipes and laminae. Atypical plants were observed in the extreme lower limits of the outlet. Though submerged, they were surrounded by *Chordaria* and subjected to both the current from the outlet and the surf which advances on the shoreline at an angle. These plants are of a pale green colour and bear many epiphytes. On July 27, 1931 large plants of a similar nature were observed in the current flowing past North Cape, Prince Edward Island.

REPORT ON THE GEOLOGY OF THE PURCELL'S COVE AREA, HALIFAX COUNTY, NOVA SCOTIA.

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(Received May 8, 1933).

ABSTRACT.

The slates of the Halifax formation form part of the roof of the Devonian batholithic intrusion, and have been considerably metamorphosed by that intrusion, the final consolidation of which took place at considerable depth below the surface. Two types of drag-folds occur, normal and reverse. It is probable that the normal drag-folds were formed during the period of folding of the Halifax-Goldenville formation, and that the reversed drag-folds were formed by the upward force of the magma. The sediments contain large amounts of iron pyrites, appearing definitely as a replacement product, and were a component of the hydrothermal stage of the intrusion. The granite is definitely porphyritic in texture, and in the south of the area is much more coarsely crystalline than in the north. This has been interpreted as due to the domed-shape of the magma in the southern part of the area as it stoped its way upwards. A study of the contact zone shows that the mode of intrusion was by stoping.

The investigation of this area was undertaken as a class in Field Geology at Dalhousie University, for the College year 1932-33. The work was done under the supervision of Prof. G. Vibert Douglas, of Dalhousie.

Purcell's Cove lies to the southwest of North West Arm, Halifax (see Key Map). The area investigated is roughly one-third of a square mile in area, and through the middle of the rectangle surveyed runs the contact zone of the granite batholithic intrusion and the sediments of the Halifax formation. The land rises from sea level to a maximum height of 200 feet, the greatest elevation being the summit of the hill in which the two granite quarries are situated. The general topography is a function of sub-aerial erosion modified by ice movement, the hills and outcrops showing a general parallelism, with the intervening valleys running generally from northwest to southeast, which was the direction of glacial movement. Actual evidences of glaciation will be discussed later.

METHOD OF SURVEY.

The type of survey used was that of regular straight line traverses. A base line running magnetic N-S was laid out for 2500 feet north of Purcell's Pond, the road and the shore line were traversed, and the three lines tied in by E-W lines. These lines were run by compass and chain.

For the actual geological survey, compass and pace lines were run from the West Boundary Line to the Road, which covered the exposed granite, while to the east of the road the traverses on the sediments were run from North to South. The actual traverse system is shown on the Key Map. The map accompanying the report shows that the Herring Cove Road follows roughly the granite-sediment contact for the greater part of the area.

The survey was run to determine, primarily, the following points:

a. The attitude of the sediments, as the roof of the batholithic intrusion.

b. The effect of the sedimentary roof on the structure and texture of the granite intrusion.

c. The effect of the intrusion on the sedimentary rocks.

d. The manner in which the batholith was intruded.

These will be discussed in the general reports on

I. The Sediments.
II. The Granite.

THE SEDIMENTS.

The sediments of the area are of pre-Cambrian age and belong to the Halifax Formation[1]. They form here part of the south limb of the Point Pleasant Syncilne[2], and have a fairly uniform dip of 30-35°N. Owing to their nearness to the granite batholith they have been intensely metamorphosed, though at even a few feet from the contact distinct bedding planes can be seen, and it is quite easy to take strikes and dips.

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[1] J. W. Goldthwait, "*The Physiography of Nova Scotia,*" p. 8. Can. Geol. Survey, Mem. 140, **1924.**

[2] E. R. Faribault, Sheet No. 68, *Province of Nova Scotia Map.* Can. Geol. Survey, **1908.**

The Dalhousie Quarry was of great help in the study of these rocks, as here there were to be had good exposures of fresh rock. Jointing is not at all uniform over the area, though it is fairly well developed. A good cleavage is developed along the bedding planes.

The exposed bedding planes of the quarry show several examples of stylolites, or washboard structure. This structure is the result of compression during the period of folding[3]. Fig. VI shows an example of this washboard structure.

Drag-folding in the area has presented some interesting if difficult problems. The major drag-folding is normal[4], and

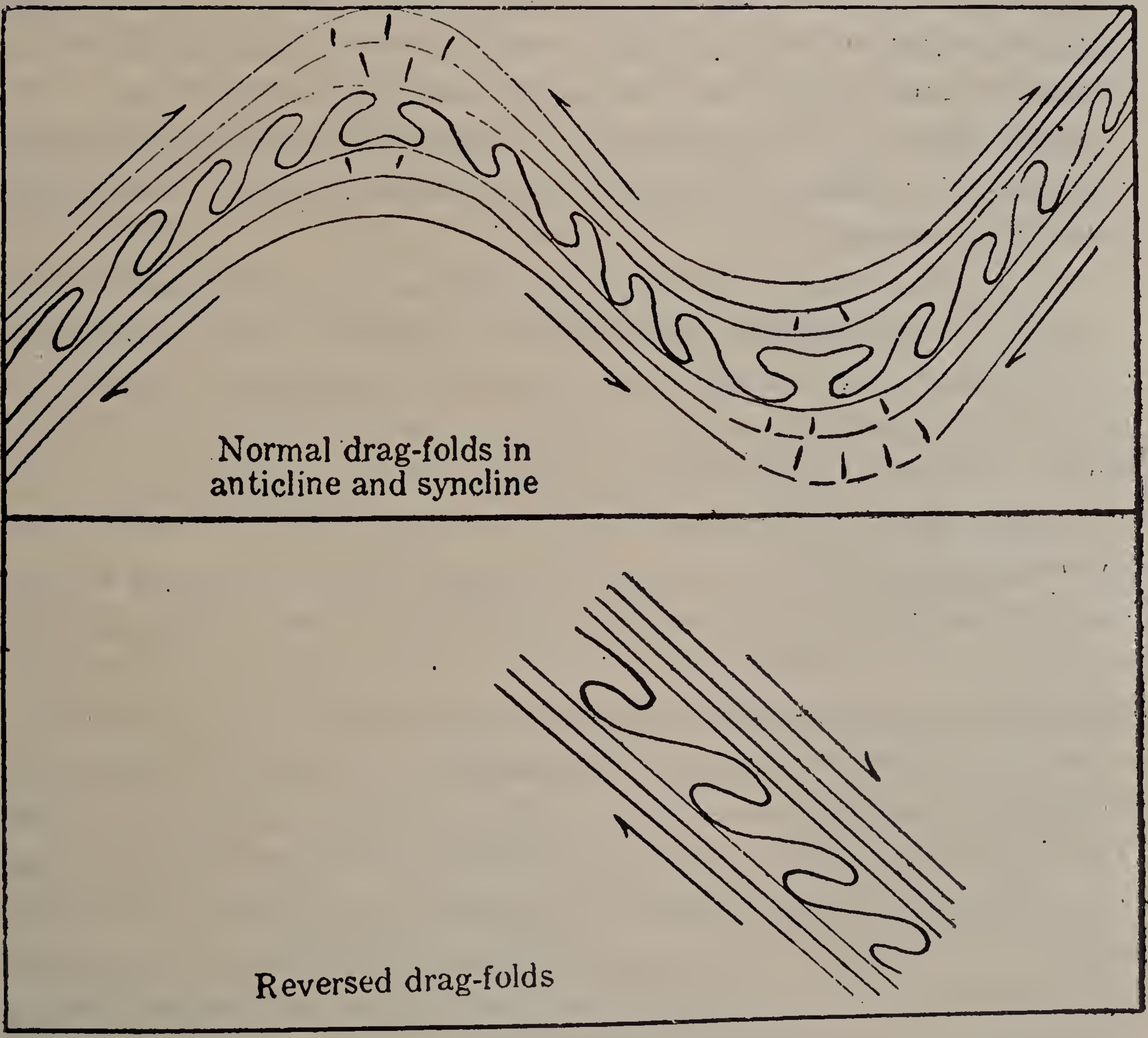

Fig. I.

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[3] B. R. MacKay, "*Beauceville Map Area*," p. 28, Can. Geol. Survey, Mem. 127, **1921.**

[4] Bailey Willis, "*Geologic Structures*," McGraw-Hill Book Company, New York. **1929.** pp. 132, 144, 168.

is developed on a comparatively large scale. A discussion of drag-folding might not be amiss here.

Drag-folding is the response of the weaker beds of a series to a tectonic movement. In the formation of anticlines and synclines in a sedimentary series it is likely that there will be some beds less rigid than the enclosing ones, and when folding occurs the upper part of the incompetent bed will follow the direction of stress of the bed above it and the lower part will follow the direction of stress of the lower bed. In this way characteristic folds are formed. Fig Ia shows the attitude of dragfolds to the opposite flanks of an anticline or syncline, as the case may be. The section through C-D (accompanying map) is an example of a drag-fold in the southern limb of the Point Pleasant syncline, the axis of which is roughly east-west.

If, however, drag folds are found to have an abnormal or reversed attitude, Fig. Ib, to the strata, one of two things must be assumed:

(a) the strata have been overturned 'en bloc', or

(b) forces other than those normal forces producing anticlines and synclines were at work, imposing a stress in a direction directly opposite to those present during the formation of a normal anticlinal structure.

This area is problematical in that distinct normal and reverse drag-folds are both to be found, the two types having been definitely determined in the field by Prof. Douglas and the writer. It is likely that the normal drag-folds were formed during the period of folding and compression, so that no overturning of the beds may be assumed. It is possible that the reversed drag-folds are the result of the granite intrusion. The granite exerted an upward force on the lower part of the enclosing beds, which resolved itself into two forces, one being along the bedding in an upward direction. This is in a direction opposite to that imposed during a period of normal folding, and thus a reversed drag-fold would be formed. This seems to account for the two types of drag-folds, and there is no reason, then, to assume overturning of the beds. In fact, the whole region shows that such a thing has not happened.

Faulting. There has been little pronounced faulting in the area. Four faults have been definitely mapped and appear to have formed when the series was comparatively young and plastic, or when a heavy overburden had given them an imposed plasticity. They can be traced for not more than twenty or thirty feet in any case, and are all normal faults with a displacement of not more than a few inches. Faulting, however, on a scale which might be said to affect the region as a whole, is not present.

Mode of deposition. The sediments in the northern part of the area, i. e., the upper part of the series, show many cases of cross-bedding, but it occurs in all directions, so that while it may be assumed that the sediments were laid down in comparatively shallow water, no conclusions may be drawn as to the direction of the shoreline of the sea of deposition. To the north of the area, along the shore of North West Arm, Prof. Douglas and the writer discovered cross-bedding on a larger scale, from which might be determined the direction of the shoreline, but we were not certain as to whether we were dealing with a very large boulder or an outcrop with its base partly eroded by the sea. It has approximately the same dip and strike as the neighbouring outcrops known to be in situ, and, if it is an outcrop, it provides good evidence that the shoreline was to the south and that the sediments were transported from that direction.

Lithology. Microscopic examination of thin sections shows that the sediments are predominantly quartzitic, with varying amounts of sericite and iron pyrites. The quartz and sericite form an allotriomorphic aggregate, and the pyrite is always to be seen as a definite replacement product Fig. VII shows pyrite replacing the other minerals

Cordierite was not identified, though several sections supposed to contain it were examined carefully.

On the eastern side of Purcell's Cove, slightly beyond the limits of the area, an interesting rock formation was observed, and on examination in thin section, it was seen to be made up of a quartzitic rock that had been heavily stained with iron oxide and in these stained areas large beautiful crystals of chiastolite were seen to have developed. Fig. VIII shows these crystals.

All over the sedimentary area there are to be seen, on joint planes at right angles to the dip and parallel to the strike, elliptical formations, from one to six or more feet along the major axis, which is parallel to the bedding planes. They are composed of a material which on a fresh fracture resembles chert. In some of these the original bedding planes are to be seen continuing through the sharply defined border to the surrounding sediments ,while in others laminations appear to have formed typical cross-bedding structure. They are typical shallow water deposits[5], the finer sediments having been rolled together in some way. In thin section there is to be seen a comparatively large amount of secondary pyrite deposition. It is possible that these inclusions were originally composed of more argillaceous material than the surrounding sediments, and were thus more susceptible to replacement by circulating waters.

Another type of 'elliptical inclusion' was found in a large erratic boulder on the shoreline. It was at first thought that the two types has a common origin, but a definite vein system was to be seen feeding these formations, which did not in all cases follow the bedding planes. They are areas where the circulating waters found a greater permeability and a wider range of replacement activity. It is possible that some of the syngenetic elliptical inclusions were modified by a similar process, but there is a distinct difference between the two types. Fig. IX shows a weathered face of a syngenetic inclusion. On weathered surfaces some of these inclusions are seen to have a noticeable white ring around the outer edge. This is a Liesegang effect and is produced by the action of meteoric waters, which formed sulphuric acid by interaction with the iron pyrites, this in turn acting on the aluminous minerals, forming kaolin[6]. In other types a surface hardening effect is to be seen. The surfaces are of a white siliceous nature, containing cavities from which the pyrites has been leached. This surface effect is due to the action of $Fe_2(SO_4)_3$ working its way up and out of the inclusion, and on the outside surface there is left only the most insoluble of the constituents.

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[5] W. H. Twenhofel, "*Treatise on Sedimentation*", The Williams and Wilkins Company, Baltimore. **1926.** p. 506 et seq.

THE GRANITE.

The granite of the area is part of the large Devonian batholith[7] which is over ninety-five miles in length, extending from Halifax through the northern part of Lunenburg County, the southern part of Kings County, down through Annapolis to Shelbourne and Yarmouth Counties. It is distinctly porphyritic in texture, the feldspar phenocrysts often attaining a length of two inches or more.

One of the most outstanding features is the difference in texture of the granites in the north and south of the area respectively. There is a fairly distinct dividing line running east and west through the area along the road running from the Herring Cove Road to the west of the quarries. The average composition of each part is similar, quartz, orthoclase and microcline feldspars, and biotite mica being the component minerals. Biotite however, forms a rather small percentage of the composition, with the orthoclase and microcline forming the greater part of the rock volume. The granite quarries afforded good opportunities for studying the structure and texture of the intrusion, and also in the securing of unweathered samples.

Several 'basic segregations' were found in the remaining quarry-blocks, but when these were placed side by side with xenoliths which were undoubtedly inclusions from the overlying sediments a distinct gradation[8] could be seen, from specimens exactly similar to the sediments at the contact to biotitic segregations so completely altered that it would have been impossible to correlate the two without the intervening types. The development of cyanite in these segregations is further proof that the processes which these segregations underwent were related to those of contact metamorphism[9]. Fig. X shows these crystals of cyanite developing in a larger grain of quartz.

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[6] W. Lindgren, "*Mineral Deposits*", McGraw-Hill Book Company, New York. **1919.** p. 327.

[7] J. W. Goldthwait, "*Physiography of Nova Scotia*", p. 12.

[8] J. F. Kemp, "*The Pegmatites*", Ec. Geol. Vol. **XIX.** No. 8. Dec., **1924.**

The jointing of the granite was mapped rather carefully, and though it might be said that there is a tendency to two sets of joints, one at about 50° and another at 110°, the area is so small and the divergences so large that no definite information may be deduced from them.

Two zones of local shearing were observed but in each case they appeared superficial and were probably a function of late cooling of the magma.

The shoreline from the granite quarry to the south boundary line gives a wonderful picture of the mode of intrusion of the magma. It is generally accepted[10] that there were three miles of Goldenville formation originally underlying the slates of the Halifax formation. There must have been a considerable thickness of Archean rock to withstand the enormous pressures of these sediments during and after their formation. Also, the total vertical thickness of the formation was considerably increased during the period of folding. The magma stoped[11] its way up through this enormous thickness of solid rock, and along the shoreline there is ample evidence to show that magmatic stoping was the means of ascent. Granite dykes are to be seen cutting the sediments in all directions, and it requires very little imagination to see the three-dimensional attitude of the granite to the sediments.

Along the shoreline, too, there are to be seen lenticular pegmatites[12] containing quartz, orthoclase and muscovite.

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[9] F. F. Grout, "*Petrography and Petrology*", McGraw-Hill Book Company, New York, **1932.** p. 356.

[10] J. W. Goldthwait, "*Physiography of Nova Scotia*", p. 8. W. Malcolm, "*Gold Fields of Nova Scotia*", Can. Geol. Survey. Mem. 156, **1924.** p. 29.

[11] R. A. Daly, "*Igneous Rocks and their Origin*", McGraw-Hill Book Company, New York, **1914.** Ch. X.

[12] F. F. Grout, "*Petrography and Petrology*", p. 69 et seq.

The crystals are large and the quartz predominates. They are similar to the pegmatites of Minnesota described by F. F. Grout, being concentrated at the edge of the granite mass, with their walls merging into the surrounding granite without marked delineation. In the north of the area there is an absence of these lenticular pegmatites, but there are several aplitic dykes cutting the granite. The majority of them are from two to three inches in width and can be traced for from ten to fifty feet, but one larger one occurs. It is well over one foot in width and can be traced for a hundred feet or more, retaining its aplitic structure throughout.

In the small quarry at the northwest of the area only one pegmatitic aggregation was observed. It is on one of the vertical faces of the quarry and is circular, about one foot in diameter. In texture it resembled the coarse-grained pegmatites, but its walls were sharply defined and it could not be determined whether, in three dimensions, it was circular, ellipsoidal, or pipelike.

In this area the complete physico-chemical history[13] of a cooling magma can be traced. The first period of cooling and solidification is represented by the granite. This orthomagmatic stage passed into the pneumatolytic stage with the formation of the pegmatites. The next stage was the hydrothermal, when the hydrothermal solutions worked their way through the sediments and deposited iron pyrites, while in the joint planes of the granite there are to be found small amounts of fluorite.

GLACIOLOGY.

The area shows distinct evidences of the Pleistocene glacial movement. The North American ice sheet spread from three or four centres[14], the main two being the upland districts, east and west of Hudson's Bay respectively. It is not known how thick this ice-sheet was in Nova Scotia, but in the Eastern United States it is known to have passed over mountains 6000 feet in height, and it may be assumed that it attained at least that thickness in Nova Scotia. In parts of the province it rearranged the old and deposited new regulus[15], but in the area under investigation there is no evidence of such a happening. The granite is for the most part bare, except for a few inches of regulus, which are undoubtedly the result of post-glacial subaerial erosion. This erosion has removed all traces of striae or chatter marks which the ice-sheet might have left on the granite.

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[13] P. Niggli, "*Ore Deposits of Magmatic Origin,*" Thomas Murby and Sons, London, **1929.** Ch. 1.

[14] J. W. Goldthwait, "*Physiography of Nova Scotia*", p. 60.

The sediments, however, have preserved perfectly the marks left by the ice. Striae and Lee and Stoss slopes are common, and there is a divergence of some fifteen degrees in the directions of the striae at different points. There are several well marked grooves, one to the east of the Dalhousie quarry being about eight feet deep, with the sides showing characteristic striation. Several large sedimentary boulders similar in composition to, and possessing the same degree of metamorphism as the sediments of the area are to be seen a short distance to the south of the Stone Pier, North West Arm. The greater part of the sediments is covered by a mantle too thick to allow detailed mapping. In the contact zone along the shoreline the grooves cut by the ice have left wonderful exposures of the granite dykes cutting the sediments, and afford a good opportunity to get a clear idea of the mode of injection of the magma.

Lee and Stoss slopes and striae show that the direction of movement was from northwest to southeast.

If the steep sides of North West Arm are examined, evidences of glaciation will be found. It can then be assumed that the existing valley is an older structure modified by the ice movement.

STRUCTURAL HISTORY TO BE INFERRED FROM OBSERVATIONS.

There is a remarkable uniformity in the dip and strike of the sediments along the contact zone, the general strike being magnetic E-W, and the dip from 30-50°N. From this it can be assumed that at the time of the intrusion there was a thickness of thousands of feet of rock above the now exposed contact zone, and that the magma stoped, rather than pushed, its way upward, appearing to favour an anticlinal structure rather than a synclinal. All along the shoreline to the south of the granite quarry the granite may be seen pushing its way in all directions into the sediments.

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[15] Idem, p. 63. Cf., J. W. Dawson, "*Acadian Geology*", Macmillan & Co., London, **1878**. Ch. V.

The xenoliths found enclosed in the granite of the quarry vary from blocks which are not more metamorphosed than the sediments at the contact to almost completely digested portions resembling basic segregations[16].

The slates of the Halifax formation were formed into their well-known anticlinal structure during the Caledonian period of mountain building[17]. From the extreme regularity of the formations it is evident that the sediments at this time were in a comparatively plastic condition, though the plasticity might have been imposed by a great weight of overlying rock. On the advent of the magma and its subsequent cooling through the orthomagmatic to the pneumatolytic stage it seems as if the sediments were rather impermeable, which would account for the lenticular pegmatites to be found along the contact zone, their further passage having been stopped by the impermeability of the sediments. Upon the advent of the magma the heat tended to indurate them and its upward force probably produced the jointing, resulting in a very much increased permeability. As a result, the later phases of the pneumatolytic stage and the solutions of the hydrothermal stage were able to permeate the country rock, and, owing to lack of any particular structural control, iron pyrites was injected almost indiscriminately through the sediments. The solutions worked their way along the jointing and bedding, and most of the pyrite is to be found as a replacement product along the bedding planes. Polished sections and thin sections confirm this.

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[16] F. D. Adams, A. E. Barlow, "*Geology of the Haliburton and Bancroft Areas, Prov. of Ontario*", Can. Geol. Survey, Mem. 6, **1910.** p. 87. H. H. Thomas and W. Campbell Smith, "*Xenoliths of Igneous Origin in the Tregastel Ploumanac'h Granite, Cote du Nord, Frence.*" Quart. Jour. Geol. Soc. London, Vol. **88,** (May, 1932). Charles H. Warren and Charles Palache, "*Pegmatites of Quincey, Mass.*", Geol. Soc. Am. **21,** p. 784. (1910).

[17] W. Malcolm, "*Gold Fields of Nova Scotia,*" pp. 39-40.

The distinct difference in texture of the granite of the north and the south of the area is to be explained by structural control. Fig V gives a diagrammatic representation of this, being a section drawn through E-F on the accompanying map. The batholith formed a great dome[18] projecting upward into the sediments. Along the contact with the roof it cooled quickly with the formation of fine-grained granite, and, in addition, during the cooling of the surface there was contraction, with the formation of aplite dykes. Later subaerial and glacial erosion have removed that portion above the present erosion surface, on which we get the two distinct types of granite.

Economic Geology.

The area has furnished no economic minerals, but large amounts of both granite and sediment have been quarried for building stone, and some thousands of tons of granite were used as filling by the Halifax Harbour Commission in the construction of the Ocean Terminals. Five quarries exist in the area, though none are at present being worked. Three are in the granite, the two large ones in the centre of the area being known as the King's and the Queen's quarries. These furnished the material for the Ocean Terminals, the Canadian Bank of Commerce in Halifax, and for several other building projects. The quarries in the sediments are the property of Dalhousie University, and furnished the stone for the facing of the buildings on Studley Campus, and the Cathedral of All Saints, Halifax. The quarry in the northwest of the area is a smaller quarry which was worked several years ago for building stone.

It has been ascertained from quarrymen who worked in the King's and Queen's quarries that the rift was along a horizontal plane, the grain on a vertical plane running approximately N-S, and the hardway a vertical plane running E-W.

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[18] F. F. Grout, "*Petrography and Petrology*", Fig. 140, p. 218.

SUMMARY AND CONCLUSIONS.

The contact of a granite batholith with the slates of the Halifax formation runs through this area. The sediments show contact metamorphism and hydrothermal replacement as a result of the intrusion. The upward force of the magma caused reversed drag-folding in some of the sediments.

The granite formed a high dome in the southern part of the area, the northern part, as at present revealed by erosion, being near the contact, and consequently finer-grained than that to the south.

Enormous masses of iron sulphide are disseminated in this area and in its vicinity, and are to be found as a replacement product in the sediments of the area.

This iron sulphide undoubtedly represents the hydrothermal stage of the magmatic differentiation.

ACKNOWLEDGEMENTS.

The writer wishes to acknowledge the help of Messrs. Sheppard, Johnston, and Sutherland, who assisted in field and laboratory investigations; of Miss Helen Belyea, who assisted in the making of thin sections; and, finally, that of Prof. Douglas, for his criticism and advice in the preparation of this report.

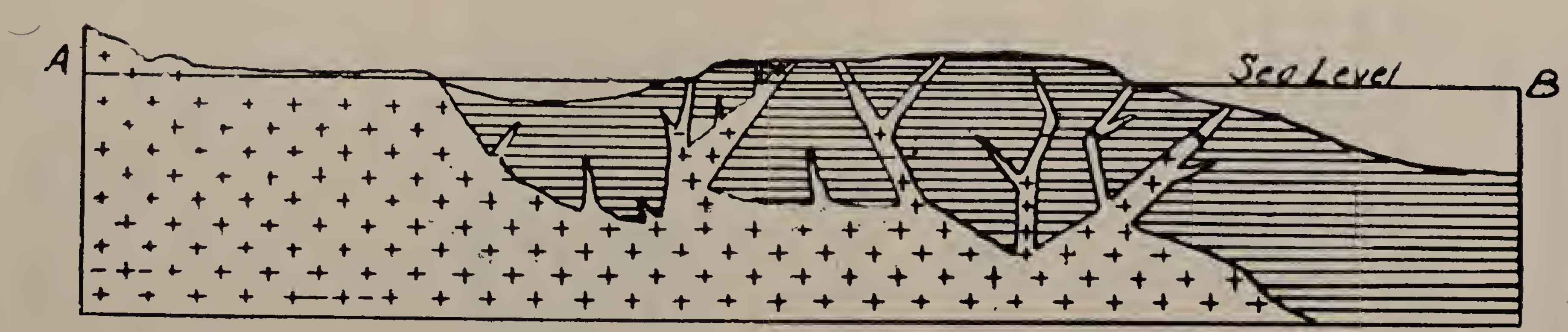


Fig. IV. Diagrammatic section through A-B.

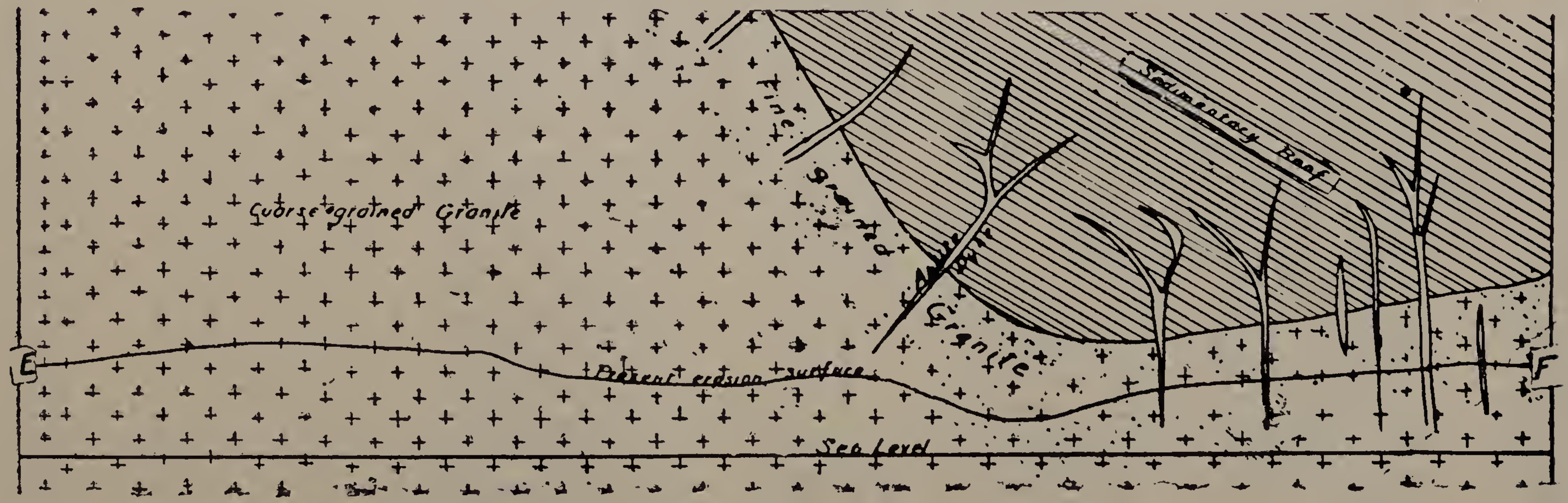


Fig. V. Diagrammatic section through E-F.
To explain difference in texture of granite in North and South of area.

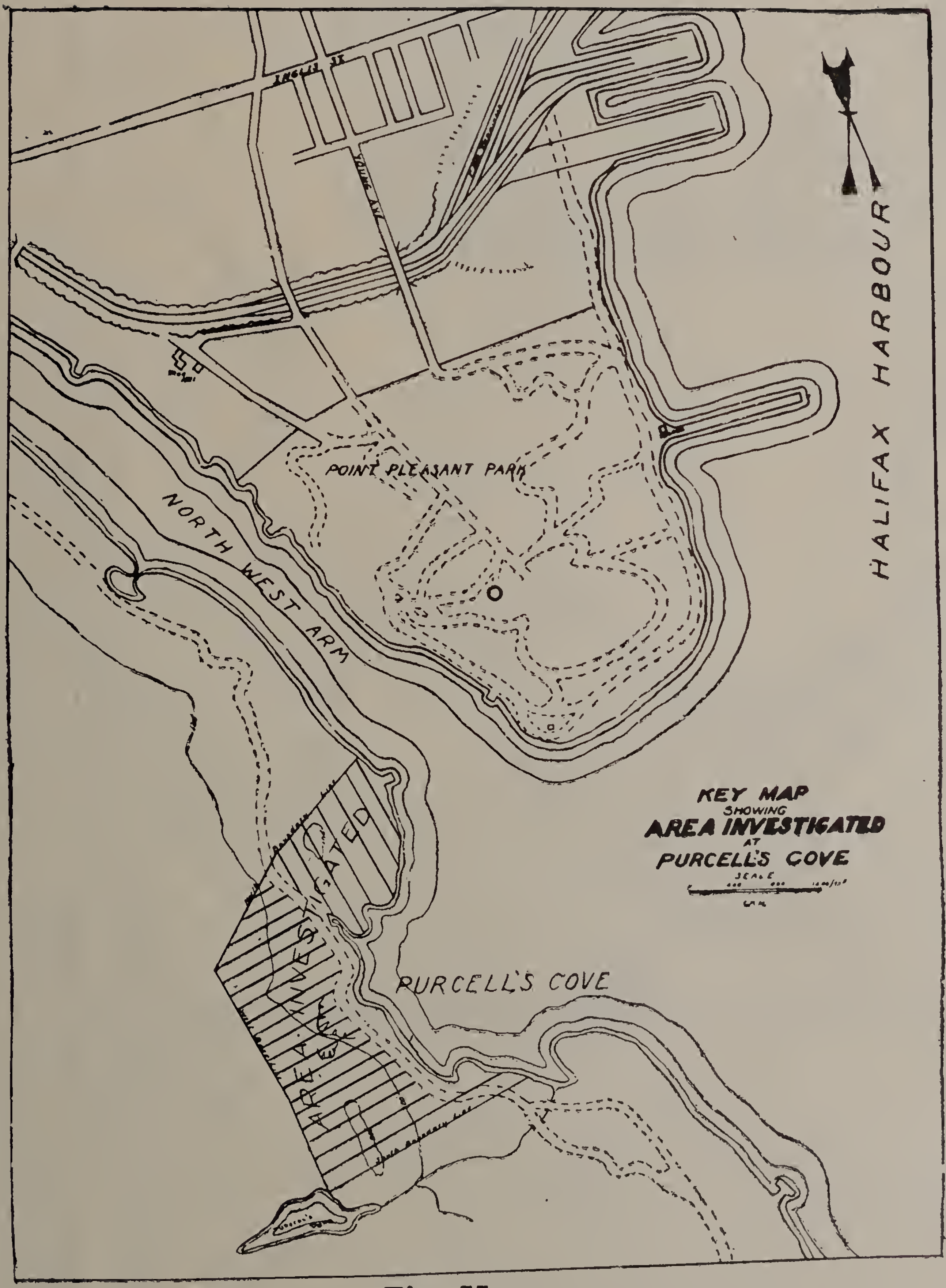
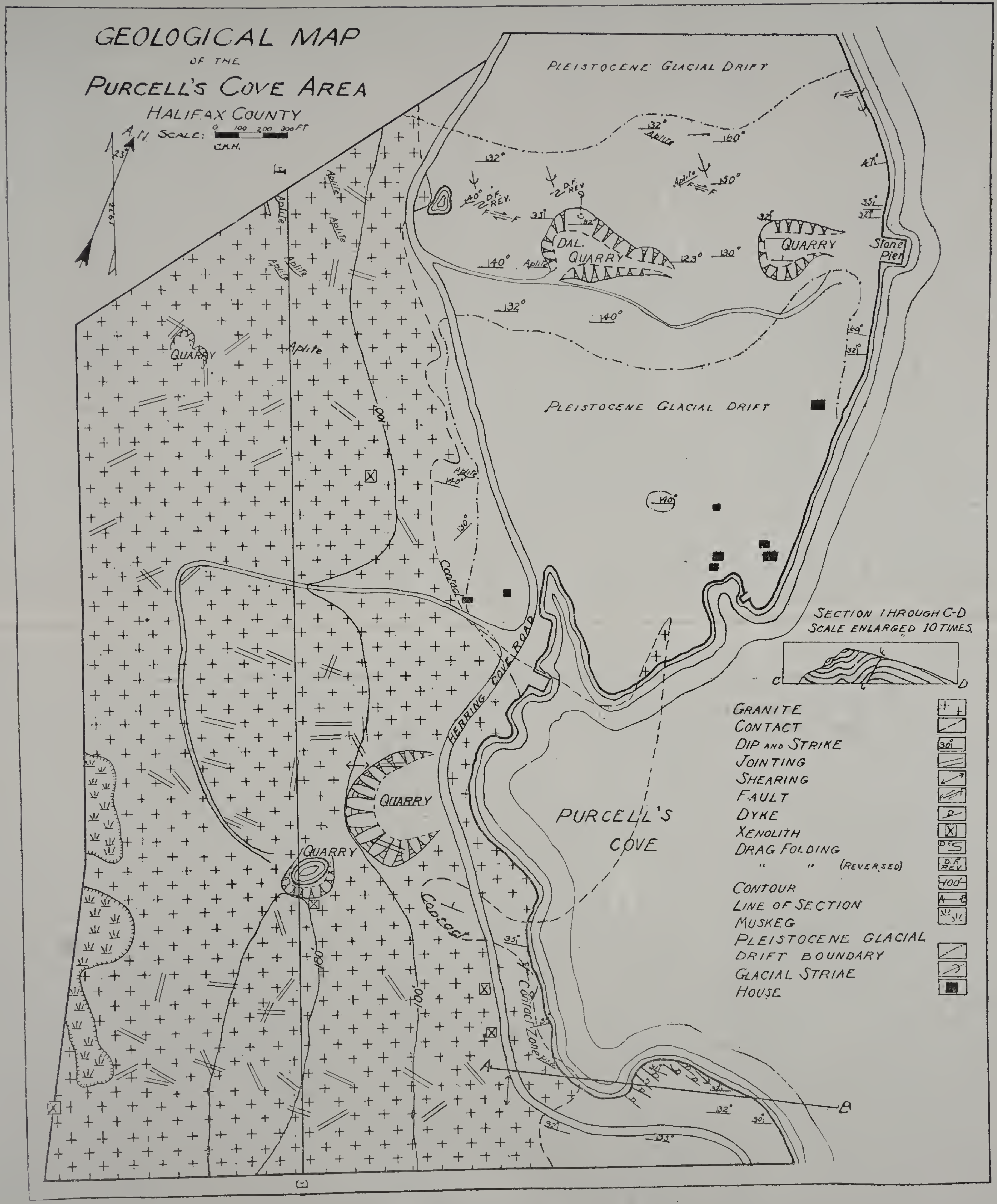

INGLIS ST
YOUNG AVE
HALIFAX HARBOUR
POINT PLEASANT PARK
NORTH WEST ARM
AREA INVESTIGATED
PURCELL'S COVE
KEY MAP
SHOWING
AREA INVESTIGATED
AT
PURCELL'S COVE
SCALE

Fig. II.


GEOLOGICAL MAP
OF THE
PURCELL'S COVE AREA
HALIFAX COUNTY
A.N.
SCALE: 0 100 200 300 FT
C.K.H.
23°
1932
PLEISTOCENE GLACIAL DRIFT
PLEISTOCENE GLACIAL DRIFT
Aplite
DAL. QUARRY
QUARRY
QUARRY
QUARRY
QUARRY
Stone Pier
D.F. REV.
F
Contact
Contact
Contact Zone
HERRING COVE ROAD
PURCELL'S COVE
100
100'
100'
A
B
SECTION THROUGH C-D
SCALE ENLARGED 10 TIMES.
C
D
GRANITE
CONTACT
DIP AND STRIKE
JOINTING
SHEARING
FAULT
DYKE
XENOLITH
DRAG FOLDING
" " (REVERSED)
CONTOUR
LINE OF SECTION
MUSKEG
PLEISTOCENE GLACIAL DRIFT BOUNDARY
GLACIAL STRIAE
HOUSE
132°
160°
140°
150°
123°
130°
182°
35°
32°
47°
60°
33°

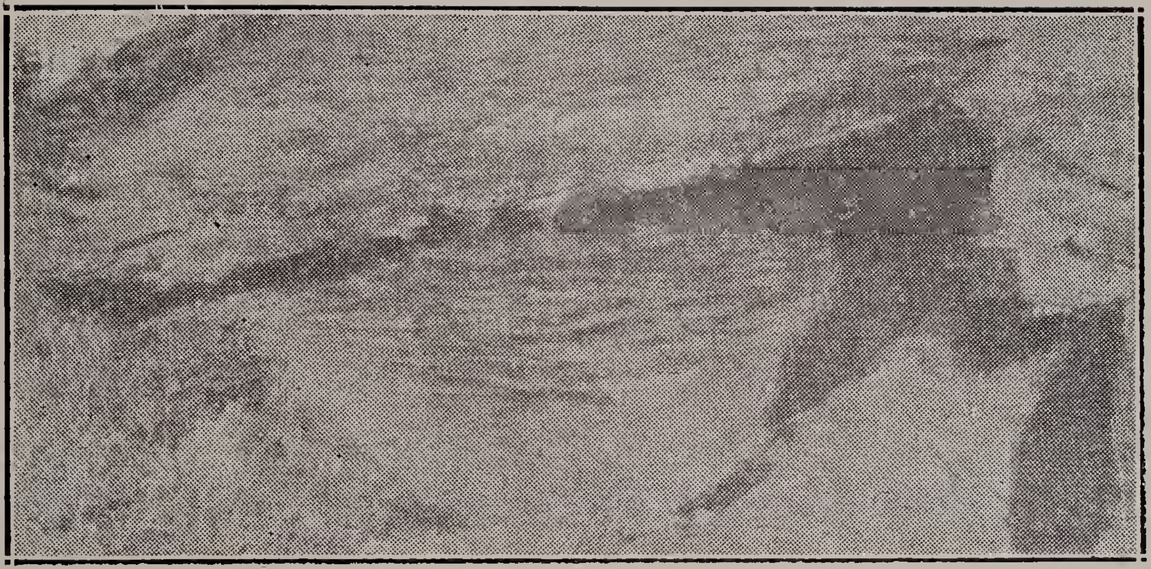


Fig. VI. Stylolites or washboard structure in sediments.

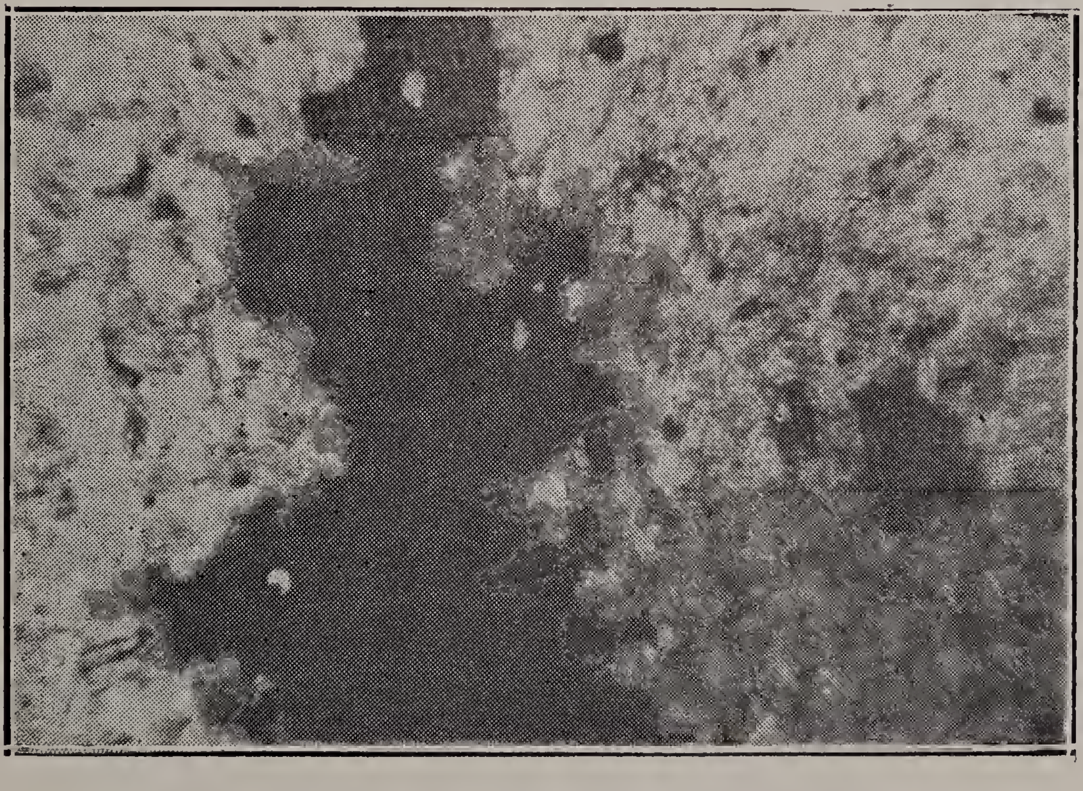


Fig. VII. Photomicrograph of pyrite replacing quartz and sericite. x100.

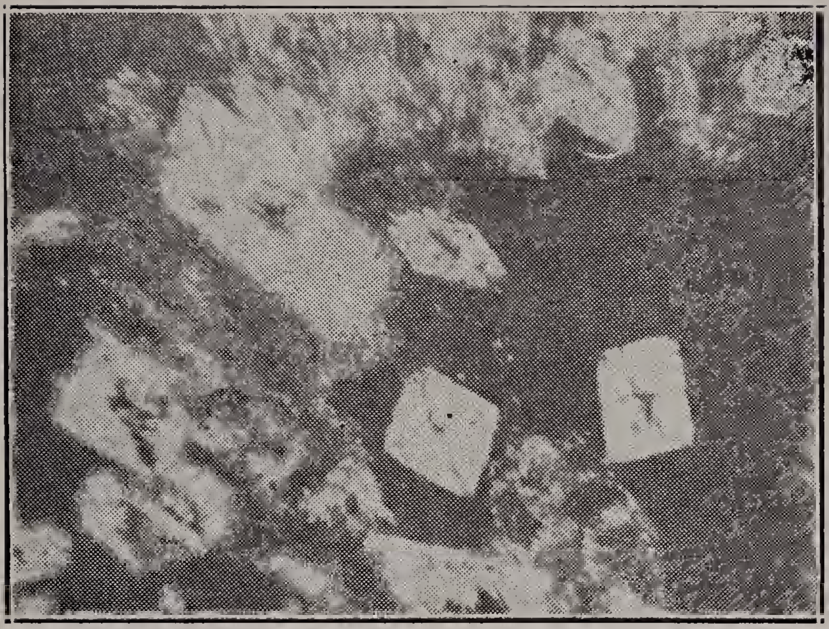


Fig. VIII. Chiastolite crystals in sediments stained with iron oxide. ×80.

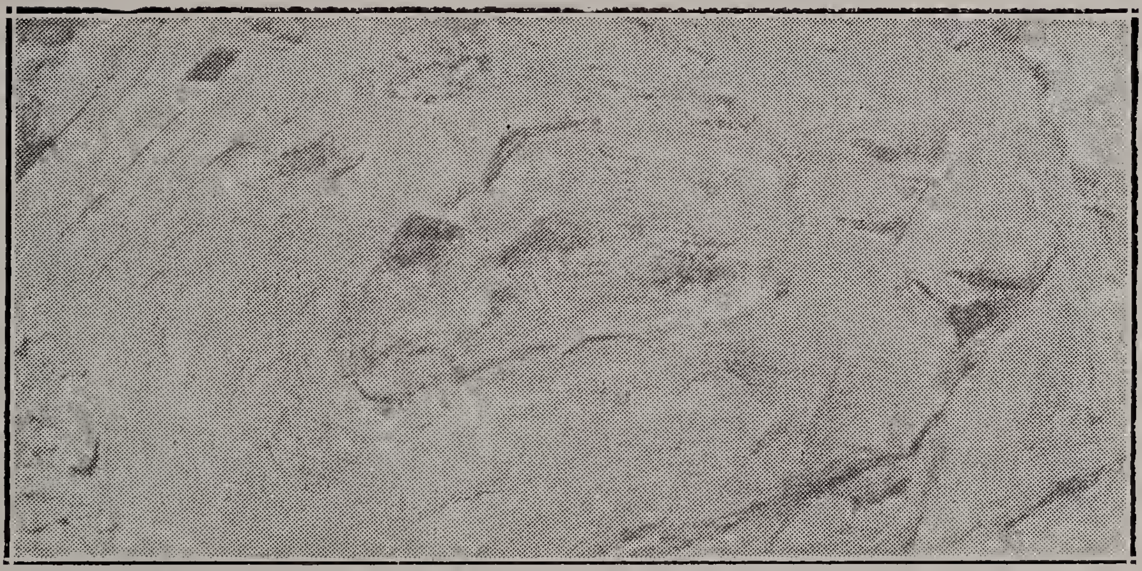


Fig. IX. Weathered syngenetic inclusion, showing Liesagang effect due to leaching.

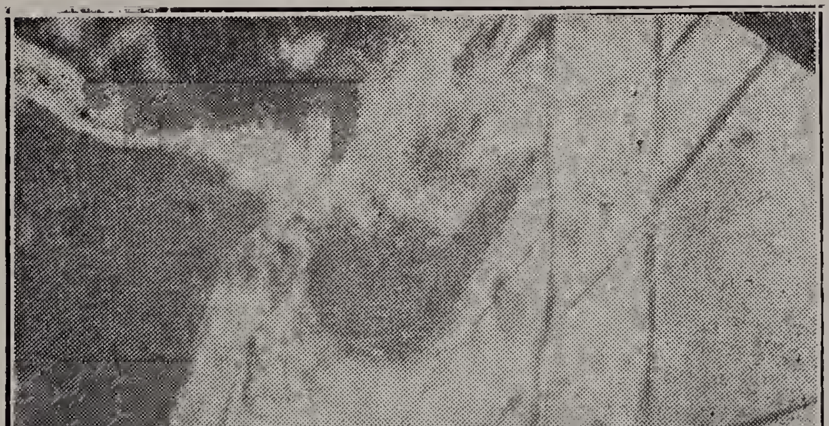


Fig. X. Photomicrograph of cyanite developing in quartz of xenolith. ×250.

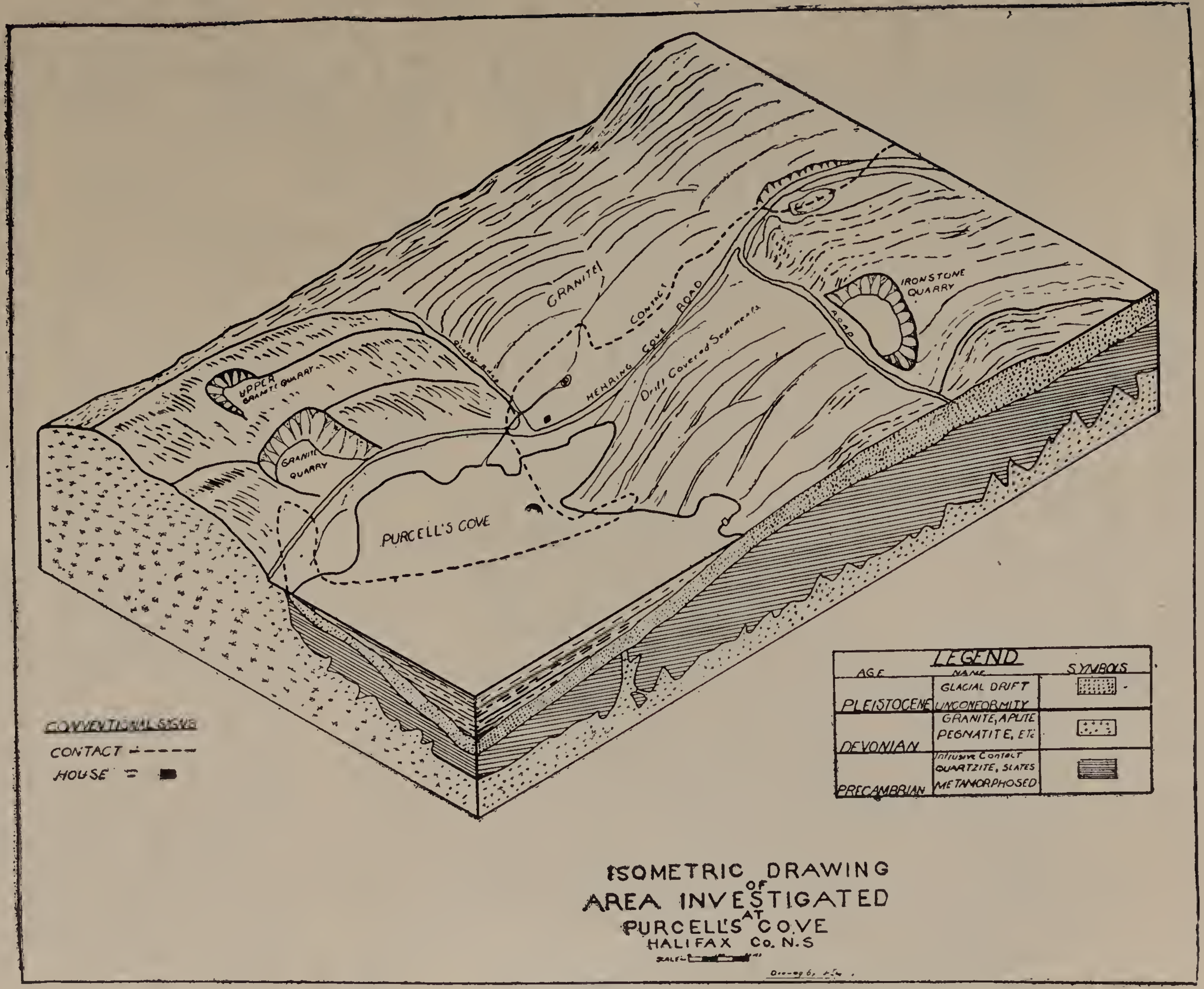

UPPER GRANITE QUARRY
GRANITE QUARRY
Quarry Road
GRANITE
CONTACT
HERRING COVE ROAD
Drift Covered Sediments
IRONSTONE QUARRY
ROAD
PURCELL'S COVE
CONVENTIONAL SIGNS
CONTACT = - - - -
HOUSE = ■
LEGEND
AGE
NAME
SYMBOLS
PLEISTOCENE
GLACIAL DRIFT
UNCONFORMITY
DEVONIAN
GRANITE, APLITE
PEGMATITE, ETC
PRECAMBRIAN
Intrusive Contact
QUARTZITE, SLATES
METAMORPHOSED
ISOMETRIC DRAWING
OF
AREA INVESTIGATED
AT
PURCELL'S COVE
HALIFAX Co. N.S
SCALE

Fig. XI.

ACCIDENTAL OCCURRENCE OF THE MAN-EATER OR GREAT WHITE SHARK *CARCHARODON CARCHARIAS* (*LINN.*) IN NOVA SCOTIAN WATERS.

HARRY PIERS,
The Provincial Museum, Halifax, N. S.

(Received June 21, 1933.)

ABSTRACT.

Hitherto *Carcharodon carcharias* (Linn.) has not been definitely reported on the coast of Nova Scotia, as Dr. H. B. Bigelow and W. W. Welsh's reference (1925) to a specimen from Banquereau is apparently an error as to locality. That record, which is based on one by F. W. Putnam (1874), is evidently referable to St. Pierre Bank to the south of Newfoundland. The species is not included in J. M. Jones's List of Fishes of Nova Scotia (1879). On 27th June, 1920, a large shark attacked an albacore-fisherman's boat off Hubbard's Cove, St. Margaret Bay, Halifax Co.; and its large size, the ferocity of its onslaught and a description of a tooth left in the wood of the boat, make it evident that it must have belonged to this species. About 2nd July, 1932, another shark of this species wantonly attacked a fisherman's motor-boat in the Bay of Fundy, ten miles northwest of Digby Gut, Ann. Co., and left some of its teeth embedded in the boat. One of these teeth has been examined and identified. It is probable that this fish was the one which was stranded at Harbour DeLoutre, Campobello Island, New Brunswick, shortly before 23rd November, 1932. It appears that, as far as is definitely known, the limit of this shark's casual range northward is about latitude 44°51′ in the northwest Atlantic Ocean, which is a little north of the latitude of Halifax; but if the St. Pierre record is accepted, the range is extended northward to somewhere between lat. 45° and 46° 50′. The paper concludes with remarks on the other sharks occurring in Nova Scotian waters.

The Man-eater or Great White Shark, *Carcharodon carcharias* (Linn., 1758), or *C. rondeletii* of Müller and Henle, 1838, as it is called in Europe, and the *Carcharias atwoodi* of Storer, 1848, as it was once designated in America, is a large, powerful, voracious and highly dangerous pelagic species which is celebrated for its ferocity and its aptness to attack man without provocation. Breder[1] says, with reference to the east coast of the United States, that the few definite and authentic records of sharks attacking man all refer to this single species. It is therefore probably the most to be dreaded of a terribly ferocious group of fishes; but fortunately for us it is exceedingly rare north of Massachusetts. In southern waters another species, the Cub Shark or Requiem, *Carcharias*

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[1] Breder, *Field Book of Marine Fishes of Atlantic Coast from Labrador to Texas*, N. Y., **1929**, 22.

commersonii (Blainville) (*C. lamia* Risso), is very greatly feared by bathers, although it usually acts as a greedy scavenger about wharves in the tropics. It occurs casually as far north as New York (Jordan, Evermann and Clark) or Massachusetts (Breder).

Range in North America—Jordan, Evermann and Clark, 1930[2], merely give the geographic range of *C. carcharias* as "temperate and tropical parts of the Atlantic and Pacific, occasionally on our coasts north to New York and Monterey Bay." It is known, however, to occasionally occur north to Massachusetts and even to Maine.

Occurrence in Nova Scotian waters.—T. F. Knight in his Descriptive Catalogue of Fishes of Nova Scotia, Halifax, 1866, and J. M. Jones in his List of Fishes of Nova Scotia, 1879[3], do not mention this species as occurring in the province. A. Halkett in his Check List of Fishes of Canada, Ottawa, 1913, only includes it hypothetically, having come upon no definite record. Dr. H. B. Bigelow and W. W. Welsh, 1925[4], however, say it "strays northward at rare intervals as far as New England and casually to Banquereau Bank off eastern Nova Scotia," and cite as their authority for the latter occurrence Putnam, Bull. Essex Inst., Salem, vol. 6, 1874, p. 72. Breder[5], 1929, following Bigelow and Welsh, also includes Nova Scotia in its range We shall have to pay some attention to this statement before proceeding further.

The "St. Peter's Bank" occurrence, about 1874.—At a meeting of the Essex Institute of Salem, Mass., on 20th April 1874, F. W. Putnam[6] exhibited a large tooth of a shark, presented by the Rev. D. P. Noyes of Pigeon Cove, who had obtained it from Andrew Johnson, one of two men who, while in a dory deeply laden with fish near "St. Peter's Bank," had been fiercely attacked by a large shark which bit at the dory, leaving marks of one jaw in the bottom of the boat and of the other on the side. The boat was tipped by the shark to such an extent as to spill part of the fish and to take in water, and was kept afloat only by vigorous bailing. Fragments of several teeth were found in the wood. A perfect tooth from the front of the lower jaw was 1.8 inch long from the centre of its root to its point, and 2.1 inches from the extreme end of its root; while the extreme width at the base, across the root, was 1.5 inch. Samuel Garman estimated that the length of the shark was more than thirteen feet, and it was believed that the species was probably *Carcharias* (*Prionodon*) *lamia*[7] or a closely allied one.

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[2] Jordan, Evermann and Clark, *Check List of Fishes of North and Mid. America*, Rept. U. S. Com. Fisheries for 1928, pt. 2, Wash., **1930.**

[3] Jones, *Trans. N. S. Inst. Nat. Sci.*, **5,** 95, (1879).

[4] Bigelow and Welsh, *Fishes of Gulf of Maine*, Rept. U. S. Com. Fisheries, Wash., **1925,** 40.

[5] Breder, *Field Book of Marine Fishes of Atlantic Coast*, N. Y., **1929,** 22.

[6] Putnam, *Bull. Essex Inst.*, Salem, **6,** 72, (1874).

This identification is not very precise, but Bigelow and Welsh[8] refer the specimen to *Carcharodon carcharias*, and no doubt correctly, as such information as we possess indicates that fierce species.

Unfortunately the location of the so-called "St. Peter's Bank" is not otherwise indicated by Putnam; but, although there is no fishing bank now so designated, one would naturally infer that the place referred to is the well-known St. Pierre Bank lying between about lat. 45° and 46°50′, and long. 55°20′ and 57°20′, off the south coast of Newfoundland, and which is washed by the southwestward flow of the Labrador Current. Pigeon Cove, from which Rev. D. P. Noyes sent the tooth, is without any doubt the small coastal village of that name in Essex Co., Mass., seventeen miles northeast of Salem and nearly four miles from the fishing port of Gloucester.

Bigelow and Welsh complicate matters by stating that the shark had "attacked a fisherman on Banquereau Bank" That they were writing of the fish mentioned by Putnam in

[7] *Carcharias lamia* of Rafinesque, 1810, is now given as a synonym of *Carcharodon carcharias*; whereas *Carcharias lamia* of Risso, 1826, and later writers, is a different species, the Cub Shark or Requiem, now known as *Carcharias commersonii* of Blainville, 1816, which rarely strays northward in the Gulf Stream as far as New York according to Jordan, Evermann and Clark, or to Massachusetts according to Breder.

[8] Bigelow and Welsh, *Fishes of Gulf of Maine*, Wash., **1925,** 40.

1874 is quite clear from their reference to the latter's note in the Bulletin of the Essex Institute before mentioned. One would therefore conclude that they had good cause for saying that Putnam's "St. Peter's Bank" was some part of the extensive and well known Banquereau, the middle of which lies in about lat. 44°30′, long. 58°20′, to the northeast of Sable Island, Nova Scotia, in which latitude we might expect to find the species on rare occasions, as a wanderer from the warm Gulf Stream.

In order to settle the question as to locality, Dr. Bigelow of the Museum of Comparative Zoology, Cambridge, was communicated with, and he informs me that he thinks he must have found something to make him change the name of the place from that given in the original record of 1874, but that he cannot now come upon any reference to the matter in his notes. Although it was the late Dr. S. Garman who identified the tooth, yet that writer does not mention it in his excellent monograph on the Plagiostomata[9], nor has a reference to it been found in any of his other papers. Dr. Bigelow's letter sums up the matter by saying, "If the locality was St. Pierre, the record becomes Newfoundland, not Nova Scotia, and of course one cannot go back of the original record."

Inquiry regarding the Noyes-Putnam specimen has been made of the Peabody Museum, Salem, Mass., to which the Essex Institute is believed to have turned over all of its scientific material. Mr. A. P. Morse, the Curator of Natural History replies that he cannot find a record of the receipt of a shark's tooth, or any tooth, from either the Rev. D. P. Noyes or the Essex Institute, in that period. So the tooth has probably been lost and no light on the subject can be obtained from that source.

Capt. C. C. Soule, Acting Hydrographer, Hydrographic Office, Washington, informs me that a careful search of the charts and other facilities of the office, fails to disclose any information concerning a fishing-bank named St. Peter's Bank, other than the one known as St. Pierre Bank. An old edition of the obsolete Hydrographic Chart No. 9, the plate of which was purchased in 1868 from E. and S. W. Blunt of New York and republished by the Hydrographic Office in that year, uses the name "St. Peter's Bank" in place of St. Pierre Bank, and there are several other instances of the use of English instead of French names.

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[9] Garman, *The Plagiostomata*, Memoirs, Mus. Comp. Zool., Cambridge, Mass., vol. 36, **1913**, 32.

Taking all of these points into consideration, I think that the balance of evidence is very strongly in favour of the opinion that Putnam's "St. Peter's Bank" is St. Pierre Bank, and that in some way Dr. Bigelow must have been mistaken in referring to it as Banquereau. The southeastern end of St. Pierre Bank is, as has been said, lat. 45° (which is the same as that of the northern edge of Banquereau) and it extends northwestward to lat. 46°50′. From Banquereau it is separated by the St. Lawrence Deep. A casual specimen could easily pass out of the northern margin of the Gulf Stream, in which it had been borne northward, and wander onto the south part of St. Pierre Bank, and yet be very little north of the accidental range of the species as we now know it.

Probable occurrence off Hubbard Cove, St. Margaret Bay, N. S., 27th June, 1920.—On 27th June, 1920, a shark, believed to be fifteen feet long, attacked the boat of Jeremiah Harnish and John Chandler of Hubbards while they were harpooning Albacore (*T. thynnus* or *secundodorsalis*) about half a mile south-southeast of the bell-buoy off Slaunwhite's Ledge, just outside and east of the entrance into Hubbard Cove, in the northwest part of St. Margaret Bay, Halifax Co., in lat. 44°36′31″ and long. 64°02′; and in so doing left a tooth in the boat. The day was a fine, warm one, with a south-southwest wind. While Harnish, Chandler and another man, Walter Winters, were out in their motor-boat, Harnish, standing on the projecting "pulpit" at the bow, harpooned what he supposed was a large Albacore. After the fish was struck, he and Chandler, as was the custom, got into their towed row-boat for the purpose of "drowning" the fish by letting it run with a buoyed line so that it would play itself out. An Albacore dives deeply when harpooned, but this fish kept only a little beneath the surface and did not attempt to run away.

About ten minutes after having been struck, it came to the surface, and when only fifteen feet away suddenly made a savage rush at the after part of the boat where Chandler was standing. The resultant impact was so great that the man was thrown overboard. The thoroughly enraged fish bit at the boat with its large powerful jaws, and left scars and cuts in the wood which were afterwards plainly seen; the spread of the jaws being about twenty-five inches. Where the upper jaw struck, just below the gunwale, was left embedded one tooth which is said to have been "as bright as ivory, as long as a man's little finger, and like the teeth of a saw on both sides." The cut in the upper part of the boat, where the tooth came into contact with the wood, was about six inches long and three-quarters of an inch deep; which is indicative of the great strength of the animal's jaws.

Fortunately the fish did not turn its attention to Chandler, who being a good swimmer soon reached the boat which was fifteen feet away, and was safely pulled in by his astonished companion. They had quite enough of the unexpected adventure and lost no time in cutting the harpoon-line so as to let the dangerous fish go; and it thereupon went off with the embedded harpoon-point and about six fathoms of the attached small rope. Winters, who was operating the motor-boat and had witnessed this affair which might have ended fatally, came alongside, took aboard the two dismayed men, and they hurried back to Hubbards, thankful for their fortunate escape[10].

When at Hubbards three weeks later, I endeavoured to obtain the tooth for careful examination, but found that in the meantime it had been accidentally dropped over the side of a wharf when being handed from one person to another for inspection. Mr. Harnish's son has sent me a sketch of it, drawn from memory, from which we learn that it was regularly triangular in form, about 1.75 inch high and about 1.50 inch wide at the base, and both edges were distinctly serrated throughout their length.

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[10] See contemporary account in a Halifax newspaper, which is now substantiated by Harnish's son, Freeman.

The fierce attack of the shark, though in this case a provoked one, and the serrated edges of its large triangular tooth, as well as the reported large size of the fish, seem clearly to indicate that it was a dreaded Man-eater (*C. carcharias*).

It may be noted that this attack on a boat in St. Margaret Bay very closely resembles one which occurred off the coast of Massachusetts, as described by Storer in 1848. A thirteen-foot shark of this species ("*C. atwoodi*") seen swimming in Princetown Harbour, Cape Cod, in June, 1848, was chased by a boat's crew and a harpoon thrown into it. Thereupon it instantly turned toward the boat and seized it with great ferocity near the bows, in doing which several of its teeth were broken off. It was eventually killed by being frequently lanced[11].

Occurrence in the Bay of Fundy, 10 *miles off Digby Gut, Ann. Co., N. S , about* 2*nd July,* 1932.—This brings us to the latest appearance of this formidable fish along our coast, to which particular attention will now be drawn.

Very early in the morning, just after dawn, of a clear day, on or about 2nd July, 1932, Wilson Munroe, a fisherman of Victoria Beach, and his young son, were in their 25-ft. motor-boat on the fishing-ground, in forty fathoms, about ten miles northwest of Digby Gut, Annapolis Co., N. S., on the eastern side of the Bay of Fundy. The latitude of the location is about 44°48′ and the longitude 65°51′. The men had stopped to overhaul their fishing trawls, it being slack water at low tide and the sea quite calm.

Fishermen in another boat which was about a quarter of a mile away saw a large shark which circled around their boat, and which they believed had been disturbed while feeding on the fish which were hooked on the trawls. Then, without the slightest other provocation, the shark suddenly and wantonly rushed at Munroe's boat. The resulting impact caused the boat to be hove up on its forward starboard (right) side;

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[11] Quoted by Bean, *Fishes of New York*, Albany, **1903, 41.**

which caused it to go downward on the after port side, the Munroes being near the stern tending their trawls. As a result, water slopped in over the port quarter gunwale. With a number of noticeable bumps against the underpart of the boat, the fish worked its way aft, under the starboard bilge; and then finally went clear. Munroe estimated that it was about thirty feet long, but it does not appear that he ever saw it distinctly. When the alarmed men came ashore and examined their boat, they found that the fish had bent the blades of the three-bladed propellor, and in so doing must have cut itself. The boat was otherwise not particularly damaged, but some of the animal's teeth were left embedded in the keel or one of the under strakes, showing that it had endeavoured to bite the boat with its powerful jaws[12]. One of these teeth was sent to the Provincial Museum, and will be later described.

This shark probably taken at Campobello Island, New Brunswick, in Nov., 1932.—Shortly before 23rd November of the same year, 1932, an unusually large shark, said to have been "the first of its kind ever taken in local waters," weighing 3,000 lbs., measuring 26 feet in length and about 6 feet in greatest diameter of body, and having a "dorsal" (probably pectoral) fin nearly 5 feet long, was taken within a "sardine" (young herring) weir at Harbour DeLoutre, Campobello Island, lat. 44°55′, long. 66°55′, in Passamaquoddy Bay, New Brunswick. It had plunged through the brush-walls of the weir and become stranded on the shore. The locality is only a few miles eastward of Eastport (lat. 44°54′), Maine, where a Man-eater Shark had been taken in August, 1872; and about fifty-one miles across the Bay of Fundy, west of the place where Munroe had been attacked in July. When opened, the Campobello specimen is reported to have had an enormous liver, which when removed filled seven fifty-gallon drums, from which exuded a great quantity of oil which was sold to an oil factory. This shark was locally believed "to be the same species which attacked a fisherman's boat in the Bay of Fundy near Digby some months before"[13]. Although the teeth of this specimen have not been examined by me, there can be little doubt that it was the individual which had attacked Munroe's boat nearly five months earlier.

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[12] This description of the shark's attack is mostly based on a verbal account by Capt. Elmer Morgan, fishery inspector, Bear River, Ann. Co., who obtained the particulars when at Victoria Beach a day or two after the incident. His account was communicated to me by Mr. J. W. D. Stearns of the *Spectator*, Annapolis Royal.

Determination of the species.—On 2nd November, 1932, the Provincial Museum, Halifax, received from Wilson Munroe one of the teeth (accession number 7508) which had been embedded in his boat. It is rather small, pure white, symetrically triangular in form, and has 21 or 22 rather conspicuous serrations or fine triangular teeth, up to .02 inch in height, on each edge. The outer surface is only very slightly convex; but the inner surface is decidedly so, the thickened ridge extending from the middle of the base to the apex of the tooth. The point is only very slightly flexed inward—so little as to be hardly noticeable. The tooth measures .71 inch in greatest height; .67 inch in middle height (from centre of the slightly concave base to apex); .50 inch in width at the base, although the original width there had no doubt been about .58 or .60 inch; and the greatest thickness of the tooth from outer to inner surface is .15 inch.

I identified this tooth as belonging to *Carcharodon carcharias* (Linn.); but owing to the great rarity of that species so very far north, and my determination being merely based on a single tooth, I wished to have the identification authoritatively verified, and therefore the tooth was sent to the U. S. Bureau of Fisheries, Washington, which referred it to the U. S. National Museum. On 5th December, Mr. Earl D. Reid, Aid in the Division of Fishes, kindly made the following report which confirms the identification: "Mr. Piers is quite correct in identifying the accompanying tooth as that of the Man-eater Shark (*Carcharodon carcharias* (Linn.)). I have compared the specimen with a jaw of this species in our collections and find that the tooth corresponds exactly with the upper lateral teeth near the posterior angle of the jaws of a specimen not more than fifteen feet in length."

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[13] *Vide* news note dated from Deer Island, N. B., 23rd Nov., 1932.

Conclusions.—We may therefore definitely include the dangerous *Carcharodon carcharias* among the fishes occurring off the southern half of our Nova Scotian coast; but its occurrence there is entirely accidental, and liable to take place in the summer or autumn. It appears that the limit of its casual range northward in the northwest Atlantic Ocean, is, so far as is definitely known, about latitude 44°55′, which is a little to the north of that of Halifax, N. S. If, however, we accept, as I believe we should, the "St. Peter's Bank" record as referable to St. Pierre Bank off Newfoundland, the range is extended further north to at least 45° or possibly even to 46°50′.

Specimens reported north of lat. 40°30′.—The following is a summary, arranged according to latitude, of the specimens of *Carcharodon carcharias* so far reported along the eastern coast of North America north of latitude 40°30′. Most of the occurrences, apart from those specially referred to in this paper, will be found noted in Storer, Proc. Bost. Soc. Nat. Hist., vol. 2, 1848, p. 71; Putnam, Bull. Essex Inst., Salem, vol. 6, 1874, p. 72; Goode, Nat. Hist. of Aquatic Animals, (Fisheries and Fishing Industries of U. S., sect. 1, text), Wash., 1884, p. 671; Stevenson, Trans. Vassar Bros. Inst., Poughkeepsie, vol. 2, pt. 1, 1884, p. 83; and Bigelow and Welsh, Fishes of Gulf of Maine, Bull. Bur. of Fisheries, Wash., vol. 40, pt. 1, 1925, p. 40.

North Latitude	Locality	Date	No.	Remarks
45° to 46°50′	"St. Peter's Bank" of Putnam (St. Pierre Bank?)	1873 or '74	1	Supposed to be 13 ft. long.
44°55′	Harbour DeLoutre, Campobello Isld. N. B.	29 ? Nov. 1932	1	26 ft. long. Probably the one met off Digby Gut in July.
44°54′	Eastport, Me., U. S. A.	Aug. 1872	1	
44 48′	10 miles N. W. of Digby Gut, Bay of Fundy, N. S.	2 July, 1932	1	
44°36′	Off Hubbard Cove, St. Margaret Bay N. S.	27 June 1920	1	About 15 ft. long.
42°25′	Massachusetts Bay, Mass., U. S. A.	1820 & after	3	6ft., 9 ft., 7 ft. 2½ in.
42°05′	Provincetown, Cape Cod, Mass.	June, 1848	1	13 ft. (*C. atwoodi*, Storer).
	Provincetown, Cape Cod, Mass.	Before 1884	4	Caught in mackerel nets.
41°45′	East Brewster, Cape Cod Bay, Mass.	16 Oct. 1923	1	16 ft. long.
41°32′	Wood's Hole, Mass.	Before 1884	Several	All small. Taken in fish traps.
41°25′	2 miles off Gt. Point Lighthouse, Nantucket Island, Mass.	4 Aug. 1883	1	10 ft. long. (Stevenson).
40°30	South Amboy, New York Bay, New Jersey.	14 July 1916	1	

That is, in the sixty years under review, the species has been noted off the south coast of Newfoundland, once, off Nova Scotia twice, New Brunswick once, Maine once, Massachusetts about 15 times, and New Jersey once.

Little danger to be generally apprehended from other sharks occurring here.—In closing, it may be noted that I have never heard, either from fishermen, pilots, Indians, or others, of anyone in Nova Scotia ever having received actual bodily injury from a large shark, although I have been told of a hungry school of the small and most annoyingly abundant Spined Dogfish (*Squalus acanthias*, Linn.), which comes inshore, having once bitten a man's legs while they were dangling in the water. The two other species of Dogfish (*Centroscymnus coelolepis*, Bocage and Capello, and *Centroscyllium fabricii*, (Reinhardt)) are usually confined to deep water, and are also far too small to do any serious injury.

Of the large species of shark, our commonest kind, the fairly large Porbeagle or Mackerel Shark (*Lamna nasus* (Bonnaterre))[14], which belongs to the same family as the vicious Man-eater, is harmless. The Great Blue Shark (*Prionace glauca*, Linn.) which attains a length of twelve feet, appears to be moderately common and occasionally quite plentiful, for instance in 1920, along our Atlantic coast in late summer and autumn, but does not seem to be at all disposed to attack man, although ravenously taking food and also bait on a large hook. Its otherwise phlegmatic and unresentful nature may be realized from the fact that one of the many off Halifax in 1920 was pierced through with an iron harpoon and yet it swam about while so transfixed and even came to eat scraps thrown to it from a pilot-boat[15]. In 1920, the year of its marked abundance, which was also the one when Harnish's boat was attacked in St. Margaret Bay, it was first noted off the mouth of Halifax Harbour on 15th August, was plentiful about 25th August, and was last seen on 10th October. These sharks were mostly about ten feet long, but among them was one (possibly another species) over twenty feet. The species has also been noted here in other years[16].

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[14] Such specimens of Nova Scotian Mackerel Sharks as I have examined, have a denticle at each side of the base of the teeth, and therefore are referred to *Lamna nasus* (*L. cornubica* Gmelin), which is the common form along the British coast, rather than to the closely related American form, *Isurus punctatus* (Storer) in which Bigelow and Welsh say the denticles are absent.

[15] Statement of Pilot E. Renner, Halifax.

The other species of shark which occur in our waters are apparently either very rare or accidental, and not at all disposed to attack man. The southern forms are liable to come north in the Gulf Stream in summer or early autumn, while the boreal ones are to be expected in winter. They are as follows: the Hammer-head Shark (*Sphyrna zygaena* (Linn.)), of which only a couple of young specimens have been taken as stragglers from the south; the Thresher Shark (*Alopias vulpinus* (Bonnaterre)) which can strike a dangerous blow with its long powerful tail, but is not often met with; the immense but dull and sluggish Basking Shark (*Cetorhinus maximus* (Gunner)), an Arctic species with very small conical teeth, which undoubtedly wanders to our coast, although I do not happen to know of an actual Nova Scotian record, but Perley states that one was taken off Musquash Harbour, seventeen miles westward of St. John, on the New Brunswick side of the Bay of Fundy, in August strange to say, 1851; and the large but very sluggish Sleeper Shark, Nurse, or Greenland Shark (*Somniosus microcephalus* (Block and Schneider)), apparently quite harmless to man, of which at least one was taken off Halifax in February, 1863, as described by Jones, and which very likely was more frequent in early years[17].

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[16] See Prov. Museum acc. nos. 3778, Sept., 1909; 4940, 23 Sept. 1920; and 4941, 10 Oct., 1920.

[17] The nomenclature of this paper is that of Jordan, Evermann and Clark, *Check List of Fishes of North and Middle America*, Rept. U. S. Com. of Fisheries for 1928, pt. 2, Wash., Feb., **1930**, pp. 1-670.

SIDE-CHAIN CHLORINATION OF TOLUENE.

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(Received Oct. 9, 1933).

ABSTRACT

When chlorine is bubbled into boiling toluene the amount of chlorine used may be gauged by the temperature (thermometer in liquid). This method is more convenient than previous methods such as the increase in weight of the reaction mixture, loss of weight of the chlorine cylinder, or increase in specific gravity. The boiling point curve of toluene-benzyl chloride mixtures is plotted. In the chlorinations described, when the temperature has reached 145°C., the composition is 21% toluene, 70% benzyl chloride and 9% benzal chloride. At 155°C. the composition is 12% toluene, 70% benzyl chloride and 13% benzal chloride. These values were obtained by fractionally distilling the products and determining the weight and refractive index of each fraction. The relation between refractive index and composition of benzyl chloride-benzal chloride mixtures is linear. The following refractive indices were determined with an Abbé refractometer: toluene $n_D^{20} = 1.4971$, benzyl chloride $n_D^{20} = 1.5391$ and benzal chloride $n_D^{20} = 1.5502$.

In these studies on the chlorination of toluene we have investigated certain modifications of technic which have wide application to chlorinations in general. A new method for the control of the amount of chlorine used has been devised and, as a suitable method of analyzing the product of chlorination, it has been found satisfactory to fractionate the product and determine the composition of each fraction from its refractive index.

Various methods have been proposed for controlling the amount of chlorine used in chlorinations. The earliest method, before the advent of cheap liquid chlorine, was to bubble chlorine, prepared usually from pyrolusite and hydrochloric acid, into the reaction flask until a definite gain in weight had been attained. The gain in weight does not correspond exactly with the amount of chlorine used in the case of the chlorination of toluene because weight is lost in the evolution of hydrogen chloride. The true weight of chlorine may be calculated from the increase in weight by the following formula (after a correction has been made for toluene vapour carried over to the absorbers by the hydrogen chloride):

$$\text{Wt.Cl}_2 = \frac{\text{Increase in weight}}{1 - \dfrac{\text{Mol. wt. HCl}}{\text{Mol. wt. Cl}_2}} = 2.058 \text{ x Increase in weight.}$$

With cheap liquid chlorine available, it is possible to determine the amount used from the loss of weight of the chlorine cylinder. These tanks are usually heavy, making accurate weighing difficult, and the cylinder must be on the scale at the time of chlorination, which is often inconvenient.

To avoid these difficulties, it is stated[1] that in the manufacture of benzyl chloride dry chlorine is passed into boiling toluene until it has attained the requisite specific gravity.

Perhaps the simplest check on the amount of chlorine is that employed by the senior author some years ago in the manufacture of benzyl chloride, namely the temperature of the boiling reaction mixture. During the introduction of chlorine the boiling point of the liquid gradually rises and the chlorine is shut off when the temperature has reached the requisite point.

To obtain a rough idea of the composition of the reaction mixture when the chlorination is carried to certain temperatures (thermometer in liquid), the boiling points of various mixtures of toluene and benzyl chloride were determined in an apparatus somewhat similar to that used in the chlorinations, but holding only 100 c.c. of liquid. One glass bead was added to cut down superheating. The results are given in Fig. I. It is to be expected that this curve will give only an approximation to the composition of the product of chlorination because of the following factors: (1) production of benzal chloride, (2) superheating, (3) presence of HCl and Cl_2. To test the effect of HCl, dry HCl was bubbled into the boiling-point apparatus containing a sample (20% $C_6H_5CH_3$ and 80% $C_6H_5CH_2Cl$). The boiling point was reduced slightly. Whether this depression was due to the cooling effect of the gas, to cutting down superheating, or to solution was not determined.

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[1] Cohen, "*Theoretical Organic Chemistry,*" Macmillan and Co., London. **1928,** p. 406. Kyrides, *U. S. Patent,* 1,345,373.

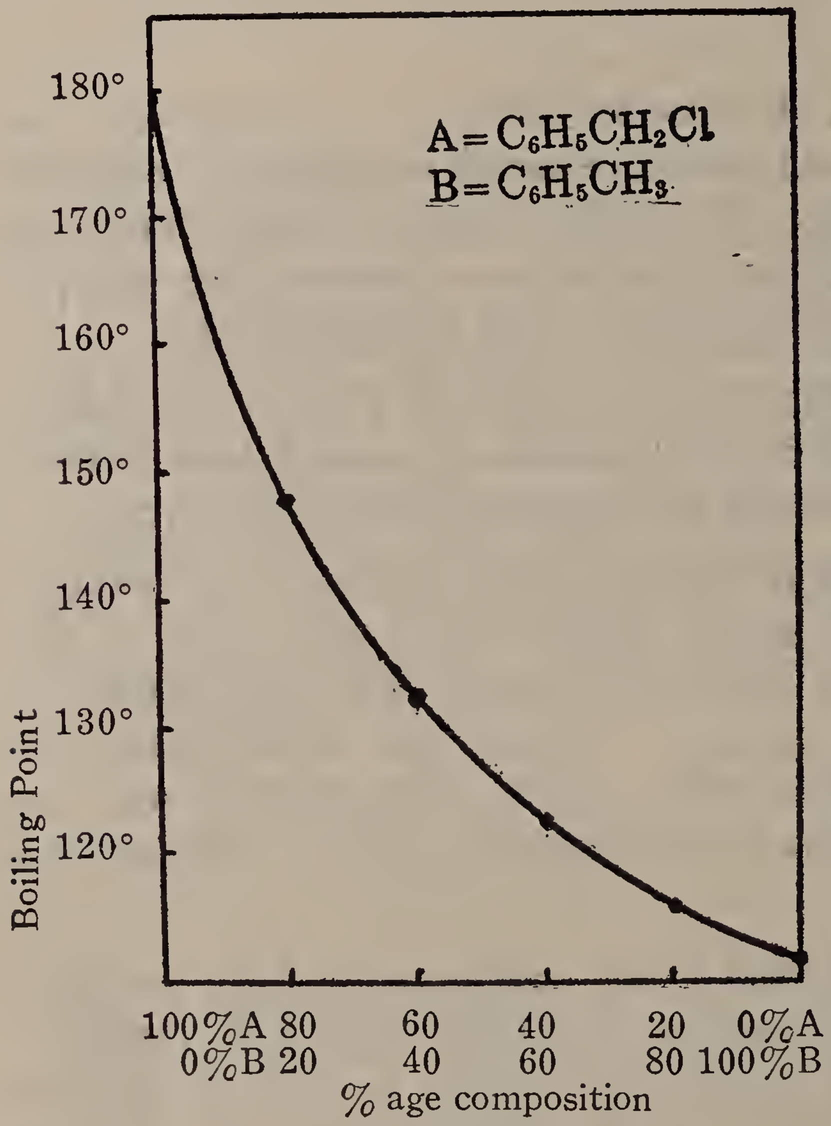

Fig. I.

From this curve two values, 145° and 155°, were chosen for checking by chlorinations on a moderate scale. Dry chlorine from a tank was bubbled into boiling toluene in a Pyrex flask fitted with a reflux condenser and containing a thermometer with the bulb immersed in the liquid. All glass connections were used. The apparatus was illuminated by a 100 watt, nitrogen-filled bulb[2]. It was found essential that every trace of water be removed before chlorination. This was done by boiling the toluene in the apparatus before the introduction of chlorine until all the water had distilled off through the uncooled condenser. Under these conditions —all glass apparatus and absence of water—, the product was practically colorless; otherwise it is often nearly black with a pronounced fluorescence. The amount of toluene condensed in the absorbers was measured at the end of the chlorination and deducted from the weight of toluene used.

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[2] The efficacy of light as a catalyst has been questioned by Book and Eggert (*Z. Elektrochem.* **29,** 521 (1923)) but Bergel (*Ber.* **59B,** 153 (1926)) found that light does accelerate the side-chain chlorination of toluene. We did not study this point in detail. In our experiments we noticed that no chlorine passed on to the absorbers and the product contained no detectable amount of the chlorotoluenes.

	145°	155°
Wt. $C_6H_5CH_2Cl$ (crude)	578.6 gms.	583.4 gms.
Wt. $C_6H_5CH_3$ (corrected)	444.5 gms.	434.3 gms.
Increase in weight	134.1 gms.	149.1 gms.
Wt. Cl_2 used in chlorination (Calc. from increase in wt.)	276.0 gms.	307.0 gms.

In order to analyze these products, they were fractionated in a partial vacuum (p = 10 cm.).

The distilling flask was heated by a metal bath resting on an electric hot-plate, the temperature of which was controlled by a rheostat. To prevent bumping one glass bead was added. During the distillation this bead danced up and down against the flask, giving off a stream of bubbles each time it touched the bottom. This method of cutting down superheating and inducing even distillation has been found to be effective in distillations generally.

Fitting into the distilling flask by a ground-glass joint was a fractionating column, 90 cm. long and 8 mm. internal diameter. In order to bring about more efficient interchange between the descending liquid and the ascending vapour, an even spiral was pressed into the tube. This column was wound with resistance wire and well insulated with asbestos paper. The temperature was regulated by a rheostat. The upper end of the fractionating column was cooled with water, the height of which was adjustable. Above the cooler, the column was bent through 180° and a condenser attached to the downward portion. This led to a receiver from which samples could be drawn without destroying the vacuum.

Three hundred grams of the sample were placed in the distilling flask. The hot-plate was heated until the reflux from the fractionating column was dripping at just a countable rate. The fractionating column was then heated until refluxing was visible in the water cooler. The level of the water was then lowered until the ratio of the drops in the reflux to those delivered to the receiver was about 10 to 1. When all the toluene had distilled over, the rate of distillation diminished and more heat had to be applied to the distilling flask and to the fractionating column to reestablish the former rate.

The course of distillation was followed by removing the distillate at intervals, weighing, and determining the refractive index by an Abbé refractometer. This refractometer was loaned to us by Mr. C. C. Forward, Dominion Government Analyst. We take this opportunity of thanking him for his kindness.

In preliminary experiments in distilling chlorinated toluene (c. p. toluene being used), the following refractive indices were measured with this instrument:

	n_D^{20}
Toluene	1.4971
Benzyl chloride	1.5391
Benzal chloride	1.5502

From these values it is possible to calculate the composition of each sample, if one assumes that the relation between percentage composition and refractive index is linear. In the case of the fractions intermediate between pure toluene and pure benzyl chloride, this assumption was made, since these fractions were so small that no significant error is introduced. The fractions between pure benzyl chloride and pure benzal chloride were larger, and it was thought best to test our assumption in this case. The linear relation between percentage composition and refractive index was found to hold. The weight of one constituent in a sample (x) is then calculated from the following formula:

$$x = \frac{ab}{c}$$

where

a = wt. of fraction, and,

in the case of $C_6H_5CH_3$ and $C_6H_5CH_2Cl$ mixtures,

b = n_D of sample — n_D of $C_6H_5CH_3$

c = n_D of $C_6H_5CH_2Cl$ — n_D of $C_6H_5CH_3$ = 0.0420

and, in the case of $C_6H_5CH_2Cl$ and $C_6H_5CHCl_2$ mixtures,

b = n_D of sample — n_D of $C_6H_5CH_2Cl$

c = n_D of $C_6H_5CHCl_2$ — n_D of $C_6H_5CH_2Cl$ = 0.0111.

Using the technic described the following results were obtained:

Chlorination of Toluene to 145°C.

Fraction	Wt. gms.	n_D^{20}	Wt. $C_6H_5CH_3$ gms.	Wt. $C_6H_5CH_2Cl$ gms.	Wt. $C_6H_5CHCl_2$ gms.
Loss in fraction.	4.89		4.89		
1	4.18	1.4971	4.18		
2	1.87	1.4971	1.87		
3	14.56	1.4971	14.56		
4	4.84	1.4971	4.84		
5	19.20	1.4971	19.20		
6	3.09	1.4971	3.09		
7	4.53	1.4971	4.53		
8	4.26	1.4971	4.26		
9	1.15	1.4971	1.15		
10	0.43	1.5111	0.29	0.14	
11	1.18	1.5389	0.01	1.17	
12	1.73	1.5391		1.73	
13	7.02	1.5391		7.02	
14	46.22	1.5391		46.22	
15	5.81	1.5391		5.81	
16	45.93	1.5391		45.93	
17	6.85	1.5391		6.85	
18	4.78	1.5391		4.78	
19	7.78	1.5391		7.78	
20	7.29	1.5391		7.29	
21	7.24	1.5391		7.24	
22	8.17	1.5393		8.02	0.15
23	7.69	1.5393		7.55	0.14
24	9.09	1.5394		8.84	0.25
25	9.21	1.5394		8.96	0.25
26	8.67	1.5397		8.20	0.47
27	9.95	1.5398		9.32	0.63
28	8.79	1.5401		8.00	0.79
29	8.49	1.5418		6.42	2.07
30	9.72	1.5462		3.50	6.22
31	7.79	1.5502			7.79
Residue	7.6				7.6
			62.87	210.77	26.36

Chlorination of Toluene to 155°C.

Fraction	Wt. gms.	n_D^{20}	Wt. $C_6H_5CH_3$ gms.	Wt. $C_6H_5CH_2Cl$ gms.	Wt. $C_6H_5CHCl_2$ gms.
Loss in fraction.	4.10		4.10		
1	1.58	1.4971	1.58		
2	2.11	1.4971	2.11		
3	28.49	1.4971	28.49		
4	0.74	1.4971	0.74		
5	0.65	1.5351	0.06	0.59	
6	1.93	1.5383	0.04	1.89	
7	1.90	1.5391		1.90	
8	3.73	1.5391		3.73	
9	50.28	1.5391		50.28	
10	7.12	1.5391		7.12	
11	49.83	1.5391		49.83	
12	7.87	1.5391		7.87	
13	45.82	1.5391		45.82	
14	8.46	1.5391		8.46	
15	8.75	1.5393		8.59	0.16
16	8.05	1.5394		7.83	0.22
17	7.76	1.5397		7.34	0.42
18	8.63	1.5401		7.85	0.78
19	7.50	1.5409		6.28	1.22
20	8.41	1.5428		5.61	2.80
21	7.07	1.5458		2.80	4.27
22	7.43	1.5497		0.33	7.10
23	6.20	1.5504			6.20
24	7.59	1.5504			7.59
Residue	8.0				8.0
			37.12	224.12	38.76

We assume that the weight of material unaccounted for by the summed weights of the fractions is toluene, the most volatile constituent. The residue is assumed to be benzal chloride, though it must have contained some benzotrichloride. These fractions are so small that no significant error is introduced in making these approximations.

The accompanying graphs, Figs. II and III, summarize the results of these analyses.

In the case of the chlorination to 145°, the combined fractions, 11 to 28 inclusive, are considered to be the yield of benzyl chloride; in the case of the chlorination to 155°, the fractions 5 to 18 inclusive. The yield of benzyl chloride in the 145°

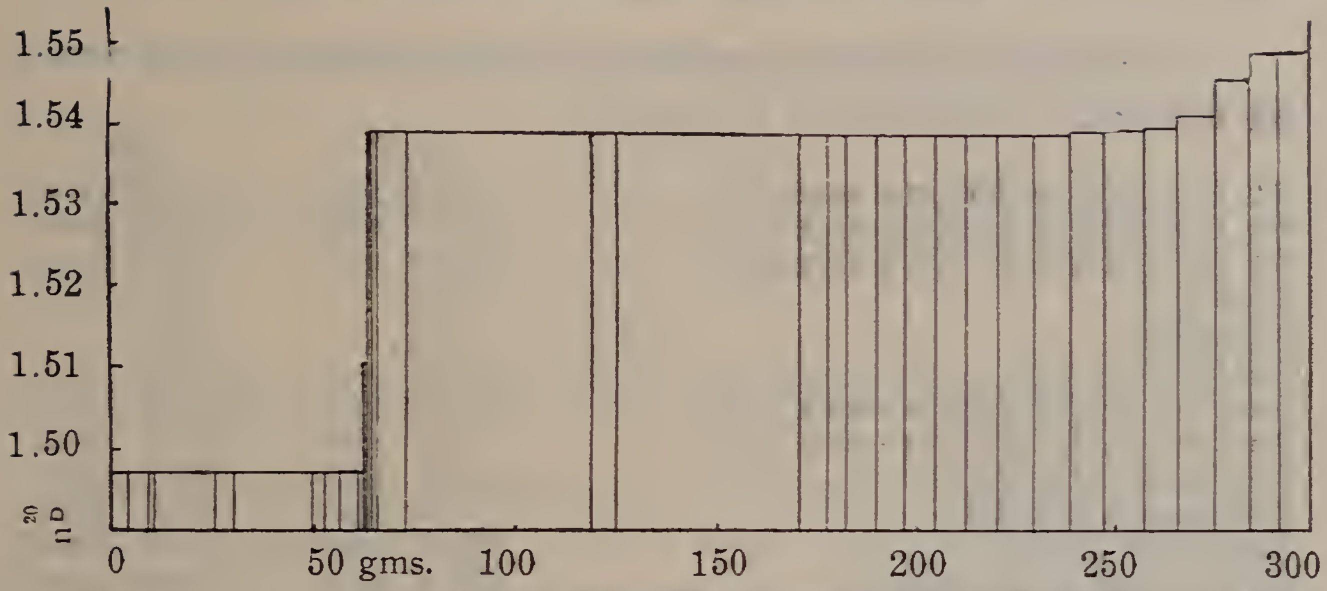

Fig. II. Fractional Distillation Graph. Chlorination to 145°C.

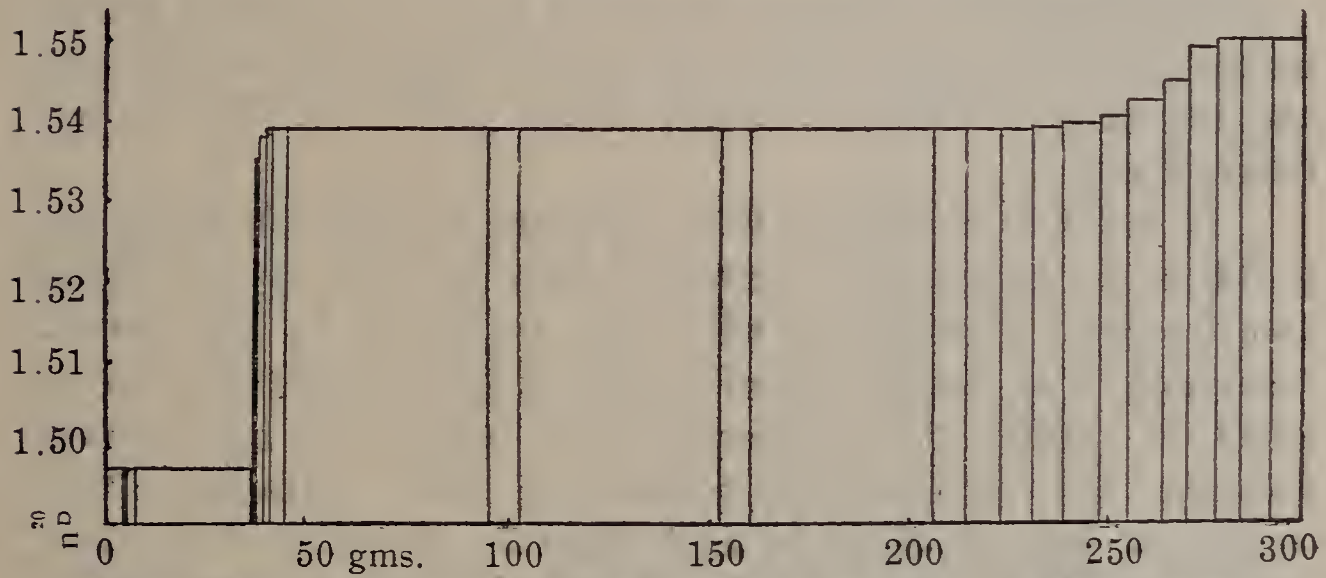

Fig. III. Fractional Distillation Graph. Chlorination to 155°C.

chlorination is calculated to be 79% and, in the 155° chlorination, 74%, based on the chlorine calculated from the increase in weight. These percentage yields are significant only in the comparison of the two runs which were as nearly identical as possible in all respects save that of the final boiling temperatures. If the ratio of chlorine to toluene vapour be increased, of course the yield of benzyl chloride will be decreased due to increased production of benzal chloride. Therefore, for maximum production of benzyl chloride, it is preferable to conduct the experiment so that the benzyl chloride can be removed from the chlorination chamber as soon as formed.

In order to check the analyses of the chlorinated mixtures, the following calculations are made:

	145°	155°
Wt. $C_6H_5CH_3$ (in 300 gm. sample)	62.87 gms.	37.12 gms.
Wt. $C_6H_5CH_2Cl$ (in 300 gm. sample)	210.77 gms.	224.12 gms.
Wt. $C_6H_5CHCl_2$ (in 300 gm. sample)	26.36 gms.	38.76 gms.
$C_6H_5CH_3$	21%	12%
$C_6H_5CH_2Cl$	70%	75%
$C_6H_5CHCl_2$	9%	13%
Total wt. $C_6H_5CH_2Cl$ in whole batch	406.5 gms.	435.8 gms.
Total wt. $C_6H_5CHCl_2$ in whole batch	50.8 gms.	75.4 gms.
Cl in total $C_6H_5CH_2Cl$	113.9 gms.	122.1 gms.
Cl in total $C_6H_5CHCl_2$	22.4 gms.	33.2 gms.
Total Cl in product	136.3 gms.	155.3 gms.
Wt. Cl_2 used in chlorination (Calc. from Cl in fractionated product)	272.6 gms.	310.6 gms.

The weight of chlorine calculated from the chlorine found in the product agrees satisfactorily with that calculated from the increase in weight, namely 276.0 gms. and 307.0 gms. respectively.

In order to determine how accurate a guide the graph on p. 206 is, the composition actually resulting from each of these chlorinations is compared with that predicted by the curve. Assuming that benzal chloride has approximately the same effect in raising the temperature of boiling as has benzyl chloride, the chlorination boiling at 145° contained 79% combined benzyl chloride and benzal chloride, while that boiling at 155° contained 88%. From the curve, it is predicted that at 145° the reaction mixture should contain 77% $C_6H_5CH_2Cl$ and, at 155°, 86% $C_6H_5CH_2Cl$, a difference of 2% in each case.

A MERCURY-IN-GLASS THERMOREGULATOR.

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(Received Nov. 1, 1933).

ABSTRACT.

A mercury-in-glass thermoregulator capable of controlling bath temperatures to within 0.001°C. is described.

The apparatus described below was developed in an attempt to eliminate some of the more obvious disadvantages of the ordinary liquid (e. g. toluene)-in-glass thermoregulator and has proved to be very satisfactory. It consists essentially of a closely wound spiral or helix (shaped to fit the bath in which it is to be used) of flattened thin-walled glass tubing which is filled with distilled mercury. (Such tubing may be obtained by special order from some laboratory glass manufacturers). Each end of the spiral is sealed to ordinary glass tubing in such a way that when placed vertically in the thermostat the tubes project above the surface of the bath liquid. One of the vertical tubes includes a stopcock (below the bath surface) while the other ends in a capillary containing a fixed pointed platinum or tungsten contact centered in the tube below the liquid surface by means of a fused on glass bead. The second platinum contact may be fused through the other tube below the stopcock which serves to regulate the amount of mercury in the system and thus change the setting of the instrument. The capillary may be open to the atmosphere or, in case a poor relay necessitates the use of a current large enough to cause sparking, may be evacuated or filled with inert gas to prevent oxidation of the mercury.

This instrument possesses several distinct advantages over the ordinary toluene regulator. The fact that the "dV/dT" is much greater in the case of the latter is of little significance in view of the fact that only the layer of toluene next to the glass wall has time to expand before the reverse change becomes necessary and the surface layer must contract to an even greater extent than it should in order to offset the expansive effect of the heat wave travelling toward the centre of the toluene. The speed of volume change is thus of greater importance than the magnitude of volume change. The former may be increased by increasing the surface volume ratio of the liquid and by using a liquid of high thermal conductivity. If the regulator is made of glass it is also important to have the walls as thin as possible. A steel spiral would probably be more satisfactory.

The following are the approximate dimensions of one of these regulators that has been in use for some months. The length of the mercury column (16 turns) is 160 cm. The width and thickness are 0.8 and 0.15 cm. respectively. The volume and surface of the mercury are approximately 19 $cm.^3$ and 300 $cm.^2$ giving about 20 times the volume and about 3 times the surface volume ratio of an ordinary Beckmann thermometer. The diameter of the capillary at the fixed platinum contact is about 0.3 mm. In a vigorously stirred bath this regulator will respond to temperature changes that are not noticeable on a Beckmann thermometer placed within the spiral, i. e. the temperature is regulated to within 0.001°.

These regulators have several other advantages over the type usually employed. They are very easy to fill—distilled mercury is simply poured into the clean spiral by means of a capillary funnel passing through the stopcock. They are easy to adjust as the contact is permanently fixed and centered in the capillary which may be made very narrow just at the platinum point. By employing only one liquid a great source of inconvenience is avoided and, as the liquid is mercury, the temperature range over which the instrument may be used is greatly increased. They take up little room in the bath, need only a small quantity of mercury and integrate over the whole depth of water more efficiently than a bulb regulator. The fact that the use of an inflammable liquid is avoided is an important consideration particularly if used to control a gas heated thermostat.

This type of thermoregulator made to specifications may be obtained from the Fisher Scientific Co. of Montreal.

PRESIDENTIAL ADDRESS.

E. Gordon Young.

(Read October 12, 1932).

It is the privilege of the president on this occasion to summarize the accomplishments of the past session and to draw to the attention of members of our society that which he may deem important.

It is my sad duty to record the loss by death of our senior corresponding member, the Reverend C. J. S. Bethune, M. A., D. C. L., F. R. S. C. on the 18th of April, 1932, in his ninety-fourth year, in the City of Toronto. Dr. Bethune was born at West Flamboro, Ontario, on the 11th of August, 1838. He received his education at Upper Canada College and Trinity University from which he was graduated in 1859. He began teaching in Trinity College School, Port Hope, and served as headmaster from 1870 till 1899. For fourteen years he was professor of entomology and zoology at the Ontario Agricultural College, Guelph, (1906-1920), He was one of the founders of the Canadian Entomological Society and the first editor of the "Canadian Entomologist." On the 18th of January, 1869, he was elected a corresponding member of the Institute. His main contribution to the entomology of this province was the description and identification of the species of Lepidoptera and Coleoptera published in our transactions for the year 1869.

Because of the belief amongst some of our members that the papers presented before the ordinary meetings of the Institute were of too technical a character to be generally enjoyed a committee consisting of Dean Burbidge and Drs. Ritchie and Johnstone was appointed to consider the advisability of reviving the popular lecture. After due consideration this committee recommended that the Institute do not undertake to provide lectures for the general public, but that the occasional popularized presentation of topics of general scientific interest could form a legitimate activity of the Institute. It was advised that such discussion should form part of the programme of the regular meetings. One such presentation was given during the session and proved of distinct interest. The practice is to be commended if it does not interfere with the communication of original papers to the Institute.

The Council has given some thought to ways and means of increasing the number of contributions for publication in the Proceedings. Enquiries have been made of various individuals in the province by way of discovering whether any work of a scientific nature of provincial importance was in progress. Certain associate members in various centres have been asked to act as unofficial representatives of the society in an endeavour to secure such contributions. In the last analysis, however, your investigating committee is in agreement with the statement in a previous presidential address to the effect that the fault lies essentially with the naturalists.

During the year six ordinary meetings of the society were held and twelve papers presented. Classified according to the different branches of science, there were six biological, (three zoological, two botanical and one bacteriological), three chemical, two pharmacological, and one physical. The rise in the number of biological papers contributed is worthy of note in contrast to the drought of recent years.

I wish to call the attention of members to the growing value and possible field of service of the Provincial Science Library of which the library of the Institute forms the major part. Not merely as an invaluable store of research information is this library now to be consulted but also as a reference source of modern information on all scientific subjects with a considerable popular appeal. Your executive has been deeply concerned by the recent fire in an adjacent building to the library and the question of adequate insurance is under consideration. The matter is recommended to the new executive as one of importance.

I have made an analysis of our membership for the past year in order to discover its diversification and the number of members actively interested. The figures are worthy of consideration. Our total enrollment is 104 which is divided into

14 corresponding members—13%,
14 associate members—13%,
76 ordinary members—74%.

The number of members nssociated with institutions for teaching or research is 73 and of these 51 are living in the Maritime Provinces. They are distributed as follows; Dalhousie-Kings 28, Fisheries Experimental Station 5, Acadia 4, Mount Allison 4, Truro Agricultural College 2, and one each from the N. S. Technical College, Memorial College, St. Francis Xavier University, St. Mary's College, University of New Brunswick, the Halifax Academy, Prince of Wales College, Provincial Science Museum.

The activity of our society is thus supported by a relatively small group of individuals of our community. It is the privilege of very few to devote much of their time to original investigation. Other than the N. S. Institute of Science there is no organization in the Maritime Provinces, to my knowledge, whose primary interest is scientific research work. Only those who have laboured at it appreciate the difficulties and discouragements. It is therefore of paramount importance that each individual of our society should look upon it as his or her duty to attend the ordinary meetings of the society although the subjects presented may be far removed from the primary interests of that individual. Such is my thesis in fostering the frail spirit of research in our community.

Of our total membership 60 members live in Halifax and 44 in more or less distant localities. Of those living in Halifax approximately 35 have attended at least one meeting in the course of the past year and so may be deemed to have an active interest in the meetings of the society. Our average attendance at an ordinary meeting is about 25. The number of members present is usually augmented by several guests. The number contributing to our programme is still smaller.

May I again be permitted to take this opportunity of offering my thanks to the members of the Institute for the honour and privilege of serving the society as president, and my grateful tribute to the members of the Council for their generous cooperation at all times.

PROCEEDINGS OF MEETINGS.

SESSION OF 1932-33.

(*All meetings were held in the Medical Science Building, Halifax*).

71*st Annual Business Meeting, Oct.* 12, 1932.—The President, Dr. E. G. Young, in the chair. Others present: D. J. Matheson, E. Hess, Dr. H. S. King, Dean G. A. Burbidge, Dr. G. H. Henderson, Capt. W. F. Mitchell, Rev. Bro. Cornelia, Prof. W. P. Copp, Dr. H. L. Bronson, Prof. C. B. Nickerson, Dr. S. G. Ritchie, Dr. J. H. L. Johnstone, Dr. F. R. Hayes, Dr. C. C. Coffin, J. M. Morton and H. Piers.

The President delivered an address in which he referred to the death of Rev. C. J S. Bethune, a corresponding member for very many years. He stated that the full membership of the Society was 104. In dealing with the nature of the papers presented during the past session, he thought that possibly some of them were too technical in character to be of direct interest to many persons, and advised that popular lectures be occasionally presented. He also drew attention to the value of the Provincial Science Library.

The Treasurer's report showed that the receipts during the past year were $1,614.42; expenditure, $218.43; balance in current account, $1,395.99; reserve fund, $225.38; and permanent endowment fund, $2,000.00. It was resolved that $500.00 be placed in the reserve fund, and $500 00 in the permanent endowment fund. The Corresponding Secretary reported that 63 back-copies of the Transactions had been sent out. A full inventory had been made of this stock of Transactions. Complete sets of vol. 1,9,11-18 (pt. 1) are still available; vols. 2, 3, 4, 6 and 8 are completely out of print, while of vol. 5, only pt. 2, of vol. 7, only pt. 4, and of vol. 10 only pts. 1, 2 and 3 are available. The Librarian's report showed that during the year ended Sept. 30, 1932, 3,343 books and pamphlets had been received through the Institute's exchange-list; and the total number in its library on that date was 66,244. The number of accessions of the entire Provincial Science Library (with which that of the Institute is incorporated) in the same period was 3,577; and the total number in the library on Sept. 30, 1932, was 86,177. During the year 870 books were borrowed. A number of books on pure and applied science had been bought, and 88 volumes of Transactions had been bound.

The following were elected officers for the year 1932-33: *President*,—Alexander Henry Leim, Ph. D.; *vice-presidents*,—

Prof. G. H. Henderson, Ph. D., and Prof. H. S. King, Ph. D.; *treasurer*,—D. J. Matheson, B. Sc.; *corresponding-secretary*,—E. Hess, M. A.; *recording secretary and librarian*,—H. Piers; *councillors without office*,—Dean G. A. Burbidge, D. J. Mackenzie, M. D., Capt. W. F. Mitchell, Rev. Bro. W. Cornelia, Prof. N. B. Dreyer, M. R. C. P., Prof. C. C. Coffin, Ph. D., and Prof. F. R. Hayes, Ph. D.; *auditors*,—Prof. W. P. Copp, B. Sc., and P. R. Colpitt.

Votes of thanks were presented to the retiring president, Dr. Young, the recording-secretary, Mr. Piers, the treasurer, Mr. Matheson, the editor, Dr. King, and the corresponding secretary, Mr. Hess.

1*st Ordinary Meeting*, *Nov*. 14, 1932.—It was announced that Prof. G. V. Douglas had been elected an ordinary member on Oct 31. A motion that a retiring president be made *ex-officio* a member of the council for the year following his term of office was lost. Dr. D. Mainland presented a paper on "A Quantitative Study of Epithelial Nuclei of the Body of the Uterus in Carcinoma and in Non-malignant Hyperplasia;" and Dr. E. G. Young and Dr. N. B. Dreyer one "On the Excretion of Uric Acid and Urate by the Bird."

2*nd Meeting*, *Dec*. 12th, 1932.—It was announced that W. Allister Crandall, B. A., had been elected a student member on Nov. 28. A paper by Prof. A. G. Hatcher, St. John's, Nfld., entitled "Note on a Rare Phenomenon in the Night Sky Seen at St. John's, Nfld., on Apr. 25, 1932," was read; as well as a note by F. B. Cubitt, S. S. "Cathcart," describing a halo, four rings and a partial rainbow, grouped about the sun, seen near the Magdalen Islands on Sept. 14, 1932. There was presented a "Report on the Programme of the Eclipse Expedition at Magog, P. Q., 1932: (a) Flash Spectrum, by Dr. G. H. Henderson; (b) Corona, by Dr. J. H. L. Johnstone."

3*rd Meeting*, *Jan*. 16, 1933.—It was announced that S. C. Carew had been elected an ordinary member on Jan. 3rd. Dr. F. R. Hayes presented a paper on "Nitrogen in Echinoid Ontogeny;" and Dr. H. L. Bronson one on "The Specific Heat of Tungsten, Molybdenum and Copper."

4*th Meeting*, *Feb*. 13, 1933.—Dr. C. C. Coffin described "Some New Physico-Chemical Apparatus," and Dr. W. W. Johnston presented a paper on "Hardened Plastics from Fish Muscle."

5*th Meeting*, Apr. 10, 1933.—It was announced that H. Roy Fraser had been elected an ordinary member on Feb. 27th. The printed Proceedings, vol. 18, pt. 2, were laid on the table.

The following papers were presented: (1) "The Odonata of the Maritime Provinces," by Dr. E. M. Walker, Toronto; (2) "The Geology of Purcell's Cove, Hfx. Co.," by C. K. Howse; (3) "Lactose Fermenting Bacteria from the Intestinal Contents of Marine Fishes," by Dr. N. E. Gibbons; and (4) "Accidental Occurrence of the Man-eater or Great White Shark (*Carcharodon carcharias, L.*) in Nova Scotian Waters," by H. Piers.

6th Meeting, May 8, 1933.—The following papers were presented: (1) "A Method of Control in the Chlorination of Toluene," by W. B. Beazley and Dr. H. S. King; (2) "Recovery of Salt from Fish Brines," by Dr. D. LeB. Cooper and R. H. Squires; and (3) "The Method of Compensating the Induced and Sub-permanent Magnetism on Iron or Steel-built Ships, with Relation to the Magnetic Compass," by Capt. W. F. Mitchell.

HARRY PIERS,
Recording Secretary.

ABSTRACTS.

(Papers read before the Institute but not published in the Proceedings.)

ON THE EXCRETION OF URIC ACID AND URATES BY THE BIRD. E. G. Young and N. B. Dreyer, Depts. of Biochemistry and Pharmacology, Dalhousie Univ., Halifax, N. S. (Read Nov. 14, 1932). A study has been made of the ureteral excretion of uric acid by the cockerel. Under luminal anaesthesia the urine is a viscous cloudy fluid containing solid matter which consists of uric acid or urate or both. The normal average flow is 6.6 cc. per hour and the variation 2-15 cc. The variation in pH is 5.0-6.8 with a mean value of 5.5. The concentration of urate is usually at a level of supersaturation, 0.2-0.7 per cent and a portion has been demonstrated to be colloidal by ultrafiltration. Under urethane anaesthesia the urine is clear, less acid and less concentrated. Birds whose ureters have been ligated die in about 24 hours and exhibit at post-mortem extensive deposits of uric acid or urate in the pleural, peritoneal and pericardial cavities and occasionally in the joints. The level of uric acid in the blood has never exceeded 0.091 per cent. Colloidal preparations of monolithium urate, injected intravenously, are recovered in the urine to the extent of between 100 and 250 per cent, monosodium urate and hexamethylenetetramine urate 40-100 per cent, piperidine urate little if at all. The extent of recovery is intimately related to the urinary volume. Of substances which might increase the solubility of uric acid in the kidney mechanism lithium carbonate is most effective, inducing marked diuresis and increasing the output of uric acid many fold. A similar action has been observed with lithium chloride, piperazine, piperidine and ethylenediamine. Methylamine, guanidine and hexamethylenetetramine were ineffective. Hypertonic solutions of glucose, sodium sulphate and sodium chloride cause a diuresis with an increase in the output of urate. Theophylline, "euphylline" and to a lesser extent caffeine, adrenaline and colchicine act similarly. Theobromine and the salicylates are without definite effect. The general conclusion is drawn that any substance which will cause a diuresis in the cockerel will increase the output of urate and tend to make the urine alkaline. No substance has been found to increase the output of uric acid by allowing a concentration of urate greater than the normal.

Cambridge Eclipse Expedition at Magog, Que., August 1932. G. H. Henderson and J. H. L. Johnstone, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read Dec. 6, 1932).

(a) By G. H. Henderson

A short description was first given of the organization and equipment of the Cambridge University Eclipse Expedition and other expeditions stationed at Magog for the total solar eclipse. A discussion was then given of the flash spectrum and the methods of observing it. Special attention was directed to the question of photographic recording of the infra-red spectrum. A report was made on the successful preliminary tests carried out at Dalhousie with Xenocyanine plates which gave a clear record out as far as the helium line of wave length about 10830 Angstroms.

(b) By J. H. L. Johnstone

A brief account was given of the various phenomena which any theory of the corona must explain. The spectrum of the corona was then discussed and the methods for observing it described. The setting up and adjustment of the large objective interferometer designed by Professor Carroll of Aberdeen University for the analysis of the green coronal line were described. A brief account of the smaller objective interferometer to be used for both the flash and coronal spectra was also given.

Nitrogen In Echinoid Ontogeny. F. R. Hayes, Dept. of Zoology, Dalhousie Univ., Halifax, N. S. (Read Jan. 10, 1933). After the penetration of a spermatozoon the developing egg receives nothing from the outside except water and sometimes salts, until the comparatively advanced embryo begins to eat. The morphological phenomena of ontogeny—intracellular reorganization, cell division, gross changes in size and shape—can only be brought about by the expenditure of energy, and this energy must come from the materials present in the egg at the time of fertilization. The problems of chemical embryology include an investigation of the chemical transformation taking place, on which virtually nothing has been done. There are two sources of energy available in the egg—proteins and lipins. Primary amino groups were found to account for nearly 40 per cent of the nitrogen in *Echinometra* eggs. Now $-NH_2$ nitrogen is known to change in metabolic processes, particularly with respect to its relation to $=NH$ and $\equiv N$ nitrogen. A study of the variation in the ratio $-NH_2$ nitrogen to total nitrogen during the first 24 hours of development was made, for the purpose of gaining some idea of whether profound protein transformations accompany cleavage, hatching, and gastrulation. Koch's modification of van Slyke's micro-apparatus was used for the estimation of $-NH_2$ groups; and micro Kjeldahl tests were made for total nitrogen. The results showed that, although there may be small variations, no major change occurs in the ratio investigated. From this it may be suspected that there is probably little change in the protein during the early stages, although a quantitative estimation of the several amino-acids present would be necessary before a definite conclusion could be reached. Since chemical changes of some sort almost certainly form a part of development, the lipins also should be studied. As to size changes during the first 24 hours, measurements of diameters (85 to 90μ) showed that the egg within the shell (or fertilization membrane) decreased in size until hatching time (6 or 7 hours), following which there was a period of rapid growth.

ON THE SPECIFIC HEATS OF TUNGSTEN, MOLYBDENUM, AND COPPER. H. L. Bronson, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read Jan. 10, 1933). A long series of determinations of the specific heats of tungsten, molybdenum, and copper have been made from —20° to 500°C. A new type of all-copper adiabatic calorimeter has been designed and used. The complete elimination of water from the calorimeter removed several sources of error and resulted in increased reliability and accuracy. Two entirely different methods were used in determining the specific heats. The usual "method of mixtures" was used to determine the mean specific heat for a large temperature change and was applied to all three metals over the entire range of temperature. The specific heat of copper was also determined for 5- or 10-degree intervals from —5° to 110°C. by heating the calorimeter electrically. It has been quite definitely shown that the specific heats of these metals over a temperature range as large as 0° to 500°C. cannot be expressed as a linear function of the temperature. An equation of the form $C_p = A + BT - C/T^2$ was arrived at from theoretical consideration s and the constants determined empirically with the following results:—

Tungsten.............. $C_p = 0.03199 + 0.00000328T - 129/T^2$
Molybdenum.......... $C_p = 0.06069 + 0.0000120T - 361/T^2$
Copper................. $C_p = 0.09292 + 0.0000136T - 452/T^2$

where the unit of heat is the 20-degree calorie and T is absolute temperature. The average deviation of the individual determinations from the values calculated by these equations was only about 0.1%. As a matter of convenience and for purposes of comparison, linear equations applicable over smaller ranges of temperature have also been given.

HARDENED PLASTICS FROM FISH MUSCLE. W. W. Johnston, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Feb. 6, 1933). A description of the methods employed and a discussion of the reactions involved in the formation of hardened plastics from waste fish were presented. Many substances of commercial use are made from casein and it has been found possible to make similar substances from fish muscle.

LACTOSE-FERMENTING BACTERIA FROM THE INTESTINAL CONTENTS OF MARINE FISHES. N. E. Gibbons, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read April 10, 1933). One hundred and twelve fishes, mostly taken in the vicinity of Halifax (2 at New Haven, Conn.) were examined for lactose-fermenting bacteria. Thirty-one strains were isolated which fermented lactose with the production of acid and gas and 3 which produced acid only. Ten strains belonged to the genus Aerobacter, 8 being Aerobacter aerogenes and 2 probably varieties of Aerobacter cloacae. Nine were soil types and the relationship of one was doubtful. Of 24 Escherichia types, 8 were fecal mammalian strains. These belonged to the species, Escherichia coli, Escherichia communior, Escherichia grünthali and Bacterium immobilis. One (Escherichia grünthali) was found in a haddock taken 3 miles off-shore; the others were found in fish taken near shore or in contaminated waters. Examination of the sea-water indicated that the offshore fish were caught in unpolluted water; the shore fish were taken in water subject to land contamination. Lactose-fermenting organisms of the coli-aerogenes type are not usually found in marine fish taken off-shore. They may be encountered in rare instances but are more common in fish taken near shore or in polluted waters.

RECOVERY OF SALT FROM FISH BRINES. D. LeB. Copoer and R. H. Squires, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read May 2, 1933). This experiment describes a possible method for the recovery of salt from brines contaminated by the process of salting fish. Recovery was attempted by the use of a semi-permeable membrane of cellophane. The results indicate that the salt diffuses readily but only one third of the protinaceous material diffuses in the time required to yield a practically saturated solution of salt inside the membrane. Graphs showing the preliminary results of the rate of diffusion of both salt and protinaceous material are given.

NOTICE TO AUTHORS.

To be printed in the volume of the year, a paper must be submitted for publication on or before the date of the May meeting.

Manuscripts should be typewritten (double spaced) on one side of the paper, 8½x11 inches, with 1 to 1½ inch margins. The original typewritten copy should be furnished.

An abstract, not over 200 words in length, must be placed at the beginning of the article. It should be suitable for reproduction in abstract journals. As an index, it should be complete; all the subjects, major and minor, concerning which new information is presented, should be mentioned. As a summary, the abstract should give briefly the conclusions of the article, important advances in experimental technique and in theory, and numerical results of general interest. For an excellent type of abstract see "The Physical Review." A summary at the end of the article should be omitted since it is included in the abstract.

Citations to the literature and notes will be placed at the bottom of the page and should be indicated in the text by superscript numerals, numbered consecutively from 1 up. All footnotes should be collected on a separate manuscript page for the benefit of the printer. The form of citations should be as indicated by the following examples:

[1] Thomson, *Phil. Mag.*, [7] **3**, 241 (1927).

[2] Bachem, *Arch. exptl. Path. Pharm.*, **122**, 69-76(1927); *C. A.*, **22**, 274 (1928). No reference should be cited which has not been consulted by the author himself. When only an abstract is available, it should be indicated in the citation as in the second case above. In abbreviating journal titles employ standard abbreviations used in such well-known abstract journals as "Chemical Abstracts." In citing books, use the form shown in the following example:

[3] Mellor. "*Inorganic and Theoretical Chemistry,*" Longmans, Green and Co., London. **1923**. vol. 4, pp. 625, 645.

In constructing tables arrange them to leave as little waste space as possible. All drawings intended for reproduction should be made about twice the size of the proposed cut on white paper. They should be drawn with extreme care, preferably by a draftsman. Material in each figure should be arranged compactly. It is well where possible to make the longer dimension horizontal. All lines that are to be reproduced must be sufficiently heavy to be clearly legible in the finished cut. When coordinate paper is used, it should be printed in blue only, with the important lines ruled over in black; the black squares in general should be not less than ten millimeters on a side in the printed cut. The lettering of cuts, when reduced, should be about the size of the letters in the text. Where necessary half-tones for reproduction on special paper will be accepted.

Unless page proofs are specifically asked for galley proofs only are sent to the author for correction. Proofs should be corrected with great care and returned by next mail to the Editor, Dr. Harold S. King, Dalhousie University, Halifax, N. S.

The Institute furnishes the author of each paper with 50 reprints without covers gratis. Additional copies may be obtained at reasonable rates if applied for at the time of return of the proof to the Editor. If covers to reprints are desired, an extra charge is made.

PROCEEDINGS
OF THE
Nova Scotian Institute of Science

SESSION OF 1933-1934
(Vol. XVIII, Part IV)

CONDITIONS OF SEDIMENTATION OF THE HALIFAX FORMATION AS OBSERVED IN POINT PLEASANT PARK.

HELEN R. BELYEA and A. WINIFRED SCOTT.
Dept. of Geology, Dalhousie Univ., Halifax, N. S.

(Received April 17, 1934).

ABSTRACT.

The Precambrian sediments in Point Pleasant Park consist of a series of alternately banded quartzites and slates. These bands are in turn finely laminated and show cross-bedding of a minute current ripple type. The rocks are metamorphosed to a certain extent and the slates have a typical spotted appearance, the spots being the residual unaltered rock. These deposits, which are some 30,000 feet in thickness, have been laid down in a broad sinking geosyncline. The rhythmical banding is the result of the rapid deposition of sands from rivers in flood followed by the slower deposition of silts after the flood season is past. These have accumulated in a shallow sea, the bottom of which has been stirred by waves and currents causing the typical cross-bedding.

The object of our work is to find a satisfactory hypothesis to explain the conditions under which the sediments of the Halifax formation were laid down. This problem resolves itself into three parts: 1. What general conditions existed to enable such a thickness of sediment to be deposited? 2. What caused the alternating beds of quartzite and slate which give the rocks their present banded appearance? 3. What is the explanation of the minute cross-bedding so prevalent throughout the area?

GENERAL GEOLOGY.

Point Pleasant Park is the southern part of the Halifax peninsula. The country is largely overlain by glacial drift and outcrops are found chiefly round the shore. The land rises from sea level to a maximum height of 100 feet. The general topography has been very much modified by military earthworks. Fig. I.

The rocks are sediments belonging to the Halifax formation which rests on the Goldenville quartzites and extends the length of the South Shore of Nova Scotia. The Halifax formation is approximately 15,000 feet in thickness[1]. The Halifax-Goldenville formations are now generally accepted as Precambrian in age. W. A. Bell[2] suggests that they may be correlated with the Avalonian of Newfoundland, a series of Precambrian sediments consisting of conglomerates, quartzites and slates. The rocks in the Park were folded during a period of mountain-building at the close of the Silurian. Thus they are now part of what is known as the Point Pleasant Syncline the axis of which runs practically east and west and plunges to the west. The outcrops on the south west shore show evidence of a minor fold with its axial plane nearly parallel to that of the major synclinal axis. During this process incompetent beds were extensively drag-folded. Very fine examples of this are to be seen near the Martello Tower. This period of mountain building was followed by the intrusion of the great granite batholith, a portion of which comes in contact with the sediments at Purcell's Cove. This intrusion came in either at the close of the Silurian or early in Devonian times. This, as well as the folding itself, is responsible for the metamorphism of the rocks from sandstone and mud to quartzite and slate. During the following Mesozoic and Tertiary eras, with the exception of a few down-warped areas where rocks of Carboniferous age have been laid down unconformably on the Halifax formation, this district must have been dry land, as there is no further sedimentation. The next event of importance in its geological history is the great Pleistocene ice sheet, when the whole country was planed off by glaciation. Several outcrops show glacial striae. In one

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[1] J. W. Goldthwait. *Can. Geol. Survey, Mem.* **140**, p. 8. (1924).

[2] W. A. Bell. *Can. Geol. Survey, Mem.* **155**, p. 22, (1929).

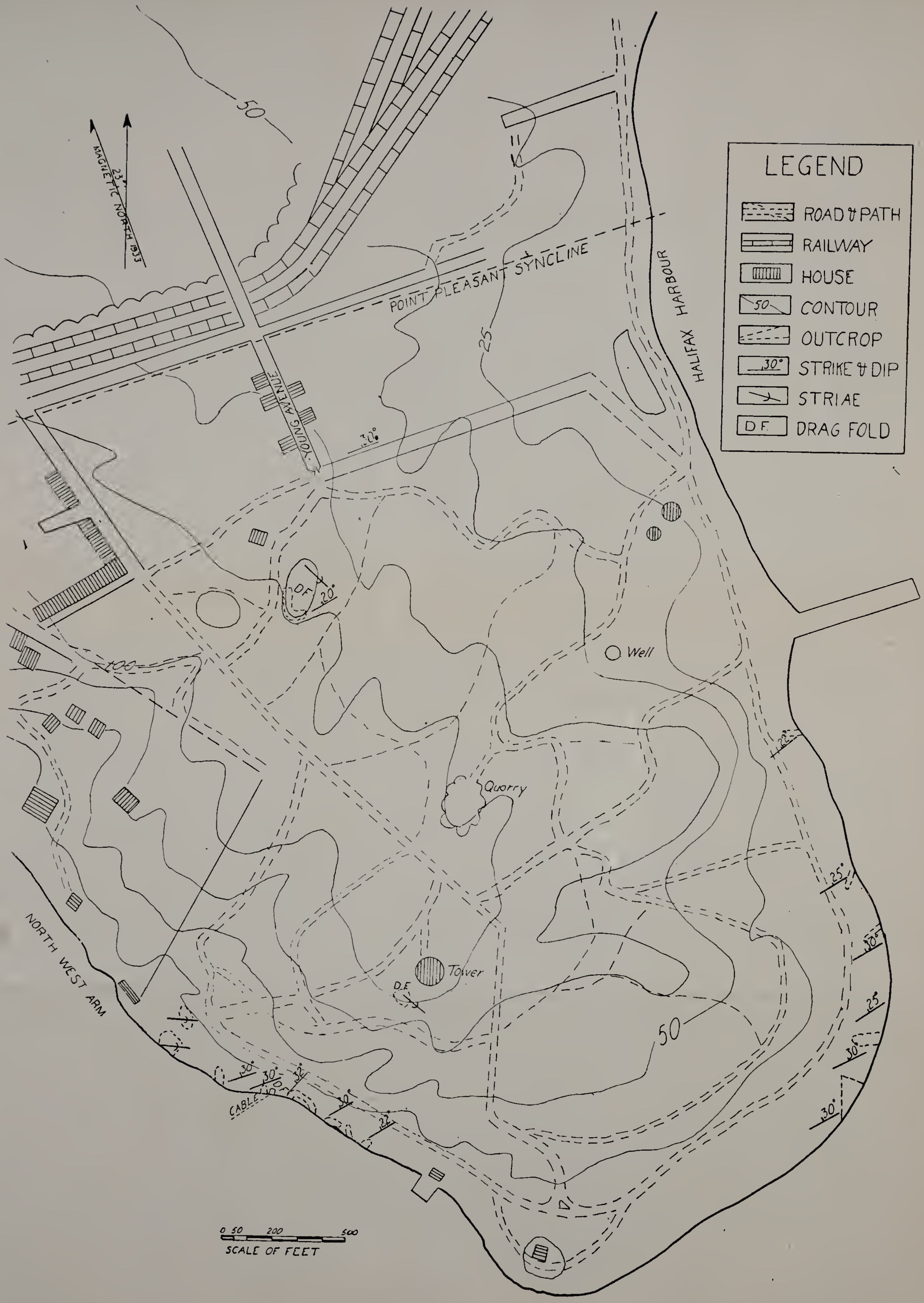
MAGNETIC NORTH 1933
23°
50
POINT PLEASANT SYNCLINE
YOUNG AVENUE
25
30°
HALIFAX HARBOUR
LEGEND
ROAD & PATH
RAILWAY
HOUSE
50
CONTOUR
OUTCROP
30°
STRIKE & DIP
STRIAE
D.F.
DRAG FOLD
D.F.
20°
100
Well
Quarry
22°
25°
30°
25
30°
30°
Tower
D.F.
50
NORTH WEST ARM
30°
30°
32°
CABLE
30°
22°
0 50 200 500
SCALE OF FEET

Fig. I.

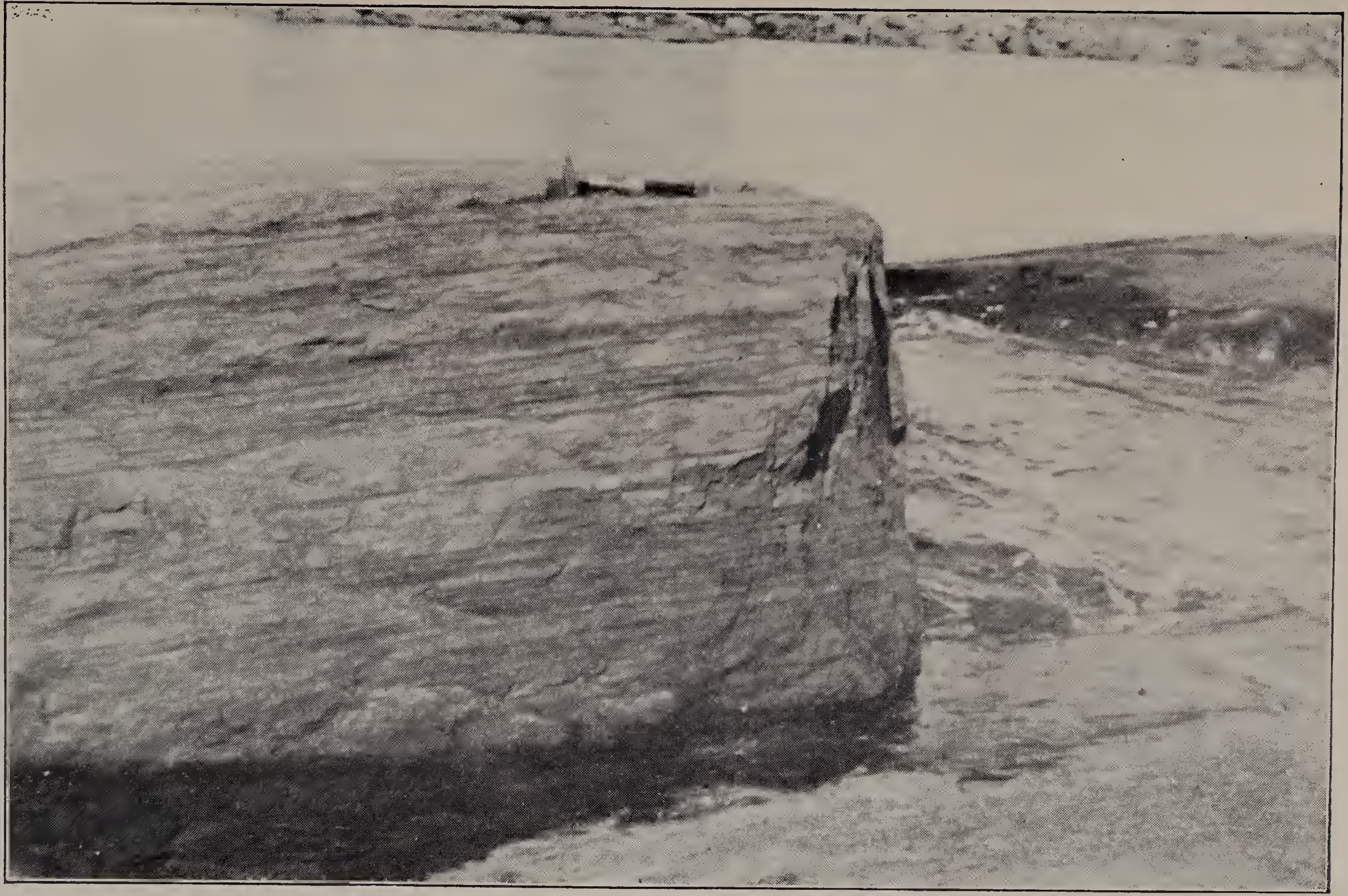

Fig. II. Rhythmic Banding Due to Seasonal Deposition.

place there is a very good example of "roche moutonnée," grooving, and plucking, caused by the passage of the ice. The ice sheet evidently advanced from north to south. This suggests that it was part of the Labrador sheet, as Dr. A. P. Coleman has postulated in his "Ice Ages Recent and Ancient"[3]. This conflicts with Grabau[4] who considers it a part of the Newfoundland sheet, but, if Grabau were correct, the glacial striae would lie east and west.

PETROGRAPHY.

The sediments in the Park present a rhythmically banded appearance. This is caused by the alternation of beds of gray quartzites with beds of slate, the quartzites usually being of a lighter colour than the slates. Fig. II. The width of these alternating beds varies from a fraction of an inch to several feet. The quartzites are as a rule thicker. These beds in turn are finely laminated with darker and lighter layers varying from microscopic proportions to perhaps a quarter of an inch in width. A microscopic examination has shown that the lighter layers consist almost entirely of quartz and that the dark laminae are caused by flakes of biotite and iron minerals.

A notable feature of the rocks is the characteristic cross-bedding which appears in the majority of the quartzite beds and many of the slate ones. "Cross-bedding is commonly present in sands and consists of their arrangement in parallel laminations transverse to the planes of general stratification the latter commonly truncating the upper edges of the laminations[5]".

Our cross-bedding is of a minute type and the foreset beds dip in all directions at varying angles. The topset beds are truncated and the foreset beds make tangents with the bottomsets, suggesting that deposition has been followed by erosion. The cross-bedding is repeated across the length of a bed and in many cases one band contains two layers of it with horizontal laminae between. The inclined beds range from one to four inches in length and show an angle of inclination of from 12° to 23°. The thin sections show a microscopic cross-bedding in several places barely visible to the eye. Fig. III.

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[3] A. P. Coleman. *Ice Ages Recent and Ancient*, The MacMillan Co., New York, **1926**, p. 11.

[4] A. W. Grabau. *Principles of Stratigraphy*, A. G. Seiler and Co., New York. **1913**, p. 326.

[5] W. H. Twenhofel. *Treatise on Sedimentation*, Williams and Wilkins Co. Baltimore. **1926**, p. 439.

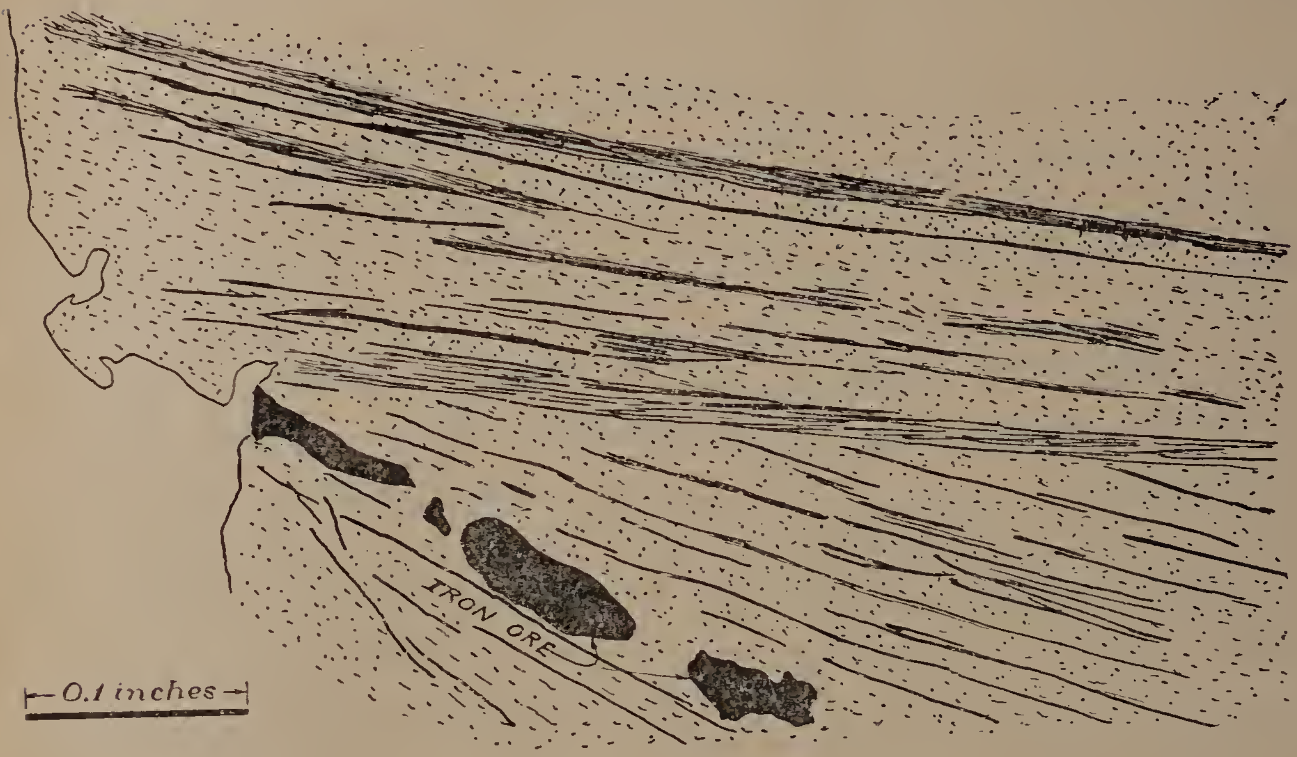

FIG. III. Enlarged Thin Section Showing Cross Bedding.

The typical quartzite beds are composed of small irregularly shaped crystals of quartz which range in diameter from an average of 0.04 mm. in some beds to 0.10 mm. in other beds. These crystals are held together by a fine sericitic cement which seems to be of the same composition as the ground mass of the slaty member. Most of the quartzite shows an abundance of biotite flakes and in some a small amount of plagioclase feldspar was observed. Both the quartzites and the slates show abundant iron minerals, chiefly pyrite, and some outcrops show a distinct iron stain. Garnet was observed in a section from a nodule.

The typical slates consist of scattered crystals of quartz and biotite embedded in a fine crystalline ground mass composed chiefly of quartz, biotite, muscovite, sericite and iron minerals. The slates present a characteristic spotted appearance.

These rocks are all metamorphosed to a certain extent, though the slates show a higher degree of metamorphism than the quartzites. This is to be expected, since the argillaceous material which forms the slates offers less resistance to heat and pressure than quartz and, furthermore, these beds are more permeable than the quartzitic beds. Metamorphism has not destroyed the original bedding planes of the quartzites but has accentuated them, since what alteration there is has tended to take place along the bedding planes leaving the interbedded portions unchanged. The alteration found here along the bedding planes is very similar to that found in the arenaceous shales of Roundout, N. Y.[6]

The successive stages of advancing metamorphism are indicated by corresponding mineralogical changes, each successive stage or zone having a characteristic mineral. Dr. Harker[7] has named the zones of progressing metamorphism according to their characteristic minerals.

ZONES OF METAMORPHISM

(0) Zone of clastic micas.
(1) Zone of digested clastic micas.
(2) Zone of biotite.
(3) Garnet zone.
(4) Staurolite zone.
(5) Cyanite zone.
(6) Sillimanite zone.

According to this classification our rocks would be placed for the most part at the end of zone (1), the zone of digested clastic micas, or perhaps intermediate between this and zone (2), the biotite zone. The abundance of biotite in the rocks would suggest this, although we are not certain to what extent this biotite is an alteration product. One of the less resistant beds shows garnet, which is typical of zone (3). The spotted slates present the most interesting problem. The spots are darker in colour than the body of the rock and are surrounded by a light halo which grades into the general ground mass. The spots are due to an accumulation of tiny black iron minerals with the extremely minute crystals of quartz and mica. The halos surrounding the spots consist chiefly of fine quartz and sericite.

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[6] R. W. Clark. *Petrographic Collection of American Rocks.* Ward's Natural Science Establishment, Rochester, N. Y., **1916**.

[7] A. Harker. *Metamorphism,* Methuen and Co., London, **1932**, p. 208.

The explanation of how these spots were formed is open to question but we believe they are residual unmetamorphosed rock which has been the last to resist alteration, rather than the spots in which metamorphism has taken its beginning and from which the alteration would be expected to spread. Our hypothesis is as follows: The argillaceous material of the ground mass has been altered and this alteration is spreading throughout the rock, the sericitic halos around the spots being the advance phase of the alteration which has not yet touched the spots to any extent. This view is further supported by the fact that the original bedding planes are quite evident in the spots though they have been completely obliterated in the surrounding ground mass. Some exhibit fracture cleavage crossing the bedding planes which is comparable to that shown by Leith.[8]

EXPLANATION.

It is impossible logically to consider the origin of these banded rocks without first forming a general picture of the conditions under which the Halifax formation was laid down. Professor Schuchert[9] has postulated that in Precambrian times the Appalachian Geosyncline covered this area, its northern shore lying in the region of the present Gaspé Peninsula, its southern following approximately the line of the Grand Banks.

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[8] C. K. Leith. *Structural Geology*, Henry Holt and Co., New York, **1913,** p. 149, fig. 52.

[9] Pirrson and Schuchert. *Introductory Geology*, John Wiley and Sons, **1924,** p. 498.

Fig. IV. If this is a correct conception these sediments are being laid down nearly in the centre of a broad shallow inland sea. In contrast to modern inland seas, the ancient geosynclines seem to have had practically flat bottoms and thus the sea was nearly the same depth over the whole area.[10]

These conditions correspond to the facts which we have observed as follows: Cross-bedding, the extent of which has already been mentioned, is essentially a shallow water phenomenon. "When aquatic, cross-bedding is indicative of shallow water marine conditions".[11] It is obvious that this must be the case since such a structure could not be developed in water too deep to be affected by waves or currents. The reasons for believing this cross-bedding to be aquatic, not aeolian, will be discussed later. Our belief is that muds and sands

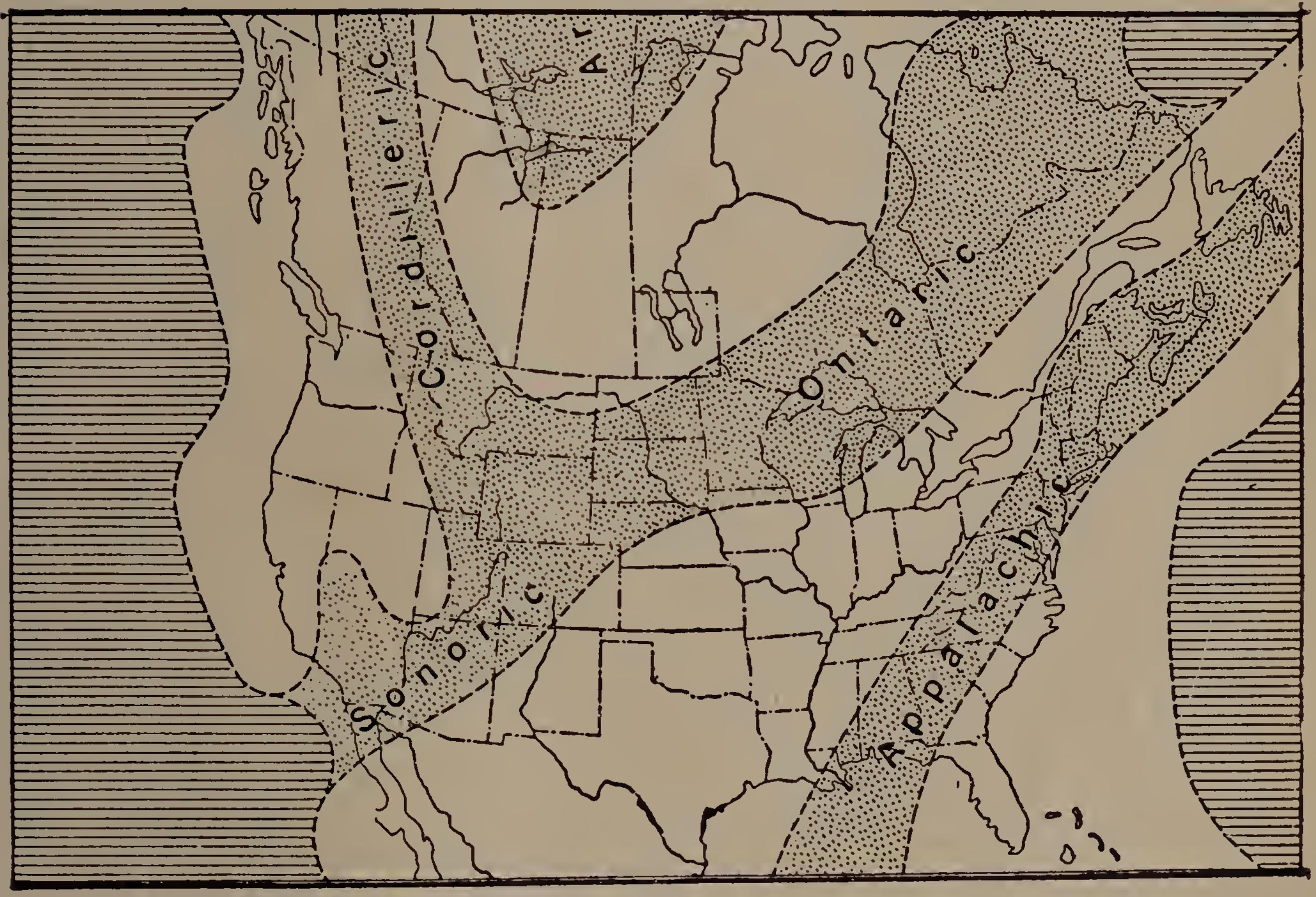

Fig. IV.
North America during the later Proterozoic. After Schuchert.

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[10] Joseph Barrell, *Bull. Geol. Loc. of Am.*, vol. 23.

[11] J. M. Marr. *Deposition of the Sedimentary Rocks*, Cambridge University Press, 1929, p. 40.

were carried down by one or more rivers and deposited beyond the delta region. The suggestion that these sediments were deposited at some distance from the shore line is borne out by the fact that no conglomerate is known either in the Goldenville or in the Halifax formation. The larger pebbles which form conglomerates are always deposited first fairly close to shore, while the finer sands and silts of which the quartzites and slates are composed are carried farther out.[12] At this point it should be noted that the Halifax formation, and the Goldenville underlying it, constitute one great series in which the Goldenville is predominantly quartzite with lesser amounts of interbedded shale. The Halifax formation on the other hand, as has been pointed out, has more shale members than the Goldenville. This order suggests that the seas, at the time when the Goldenville formation was being laid down, were deeper than the seas at the time of the deposition of the Halifax formation and thus the silts were carried further out. This points to a lag in isostatic readjustment at the beginning of this great period of sedimentation, or alternately it means that in Goldenville times rainy conditions were much more extensive than dry, whereas in Halifax times the seasons were about equally divided.

The conditions in the basin of deposition while these sediments were being laid down must have been very uniform. However, to allow a thickness of thirty thousand feet to be deposited under similar conditions in a shallow trough, the sea floor must have been slowly sinking, thus keeping the water at an approximately constant depth.[13]

If these deposits were laid down, as has been suggested, quite far out from shore, what caused the formation of alternating bands of quartzite and slate? The Baron de Geer has made a study of banded clays which he describes as the result of seasonal downwash from glaciers. In the summer when the ice is melting a quantity of material is brought down and forms a light coloured band. In the winter when less material

[12] J. M. Marr. Loc. cit., p. 79.

[13] F. F. Grout. *Petrology and Petrography,* McGraw-Hill Book Co., New York, 1932, p. 319.

is deposited a narrower dark band is formed. These bands are known as varves and form a valuable record of the annual deposition from glaciers.[14]

There are several other ways in which rhythmic banding may develop[15]. It may be due to weather changes. That is, it may be caused when the sea bottom is disturbed by storms and sand is carried out and deposited in the silt area. As conditions return to normal the sand settles into a distinct layer and mud is laid down over it again. In this way successive storms cause bands of differing materials to be formed.

It is possible that banding is also caused by climatic cycles in which a number of mild years are succeeded by years of more rigorous weather; the cycle, repeating itself, forms bands. An example of this is the Bruckner Cycle in which similar conditions recur every thirty-five years.

Rise and fall of sea level causes alternating bands of detritus. As the sea advances sands are laid down over the former conglomerate area and then muds on top of that. When the sea retreats the process is reversed. It should be made clear that by change of sea level a much more lasting condition is implied than a temporary change caused by tides or floods.

Lastly, rhythms may be caused by seasonal changes. During the flood seasons material of a certain coarseness is deposited and then in the dry season finer material is washed down over it, so that two beds represent a year's deposition.

One must consider each possibility with reference to the existing conditions in the banded rocks with which we are dealing. Firstly, could they be glacial varved clays? There are two reasons why this is not probable. Most varved clays contain an occasional striated pebble showing definitely that they are of glacial origin. We have not found a trace of one. De Geer describes varves as having a thin bed of fine material for the winter deposit and a thicker layer of coarser material for the summer. In many outcrops in the Park, on the other hand, the fine grained slate predominates over the coarser quartzites, but there is no constant relationship between the two. Fig. V.

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[14] R. W. Sayles, *Bull. Geol. Loc. of Am.*, vol. 27, no. 1, p. 111.

[15] W. H. Twenhofel. Loc. cit., p. 442.

It seems improbable that banding so uniform in nature and extending over such an area should be caused entirely by storms though it is possible that they may affect the thickness relation between certain bands.

There is no evidence to suggest that the relationship between mild and stormy years followed any definite cycle. The relationship between their thicknesses is too variable to suggest such a succession.

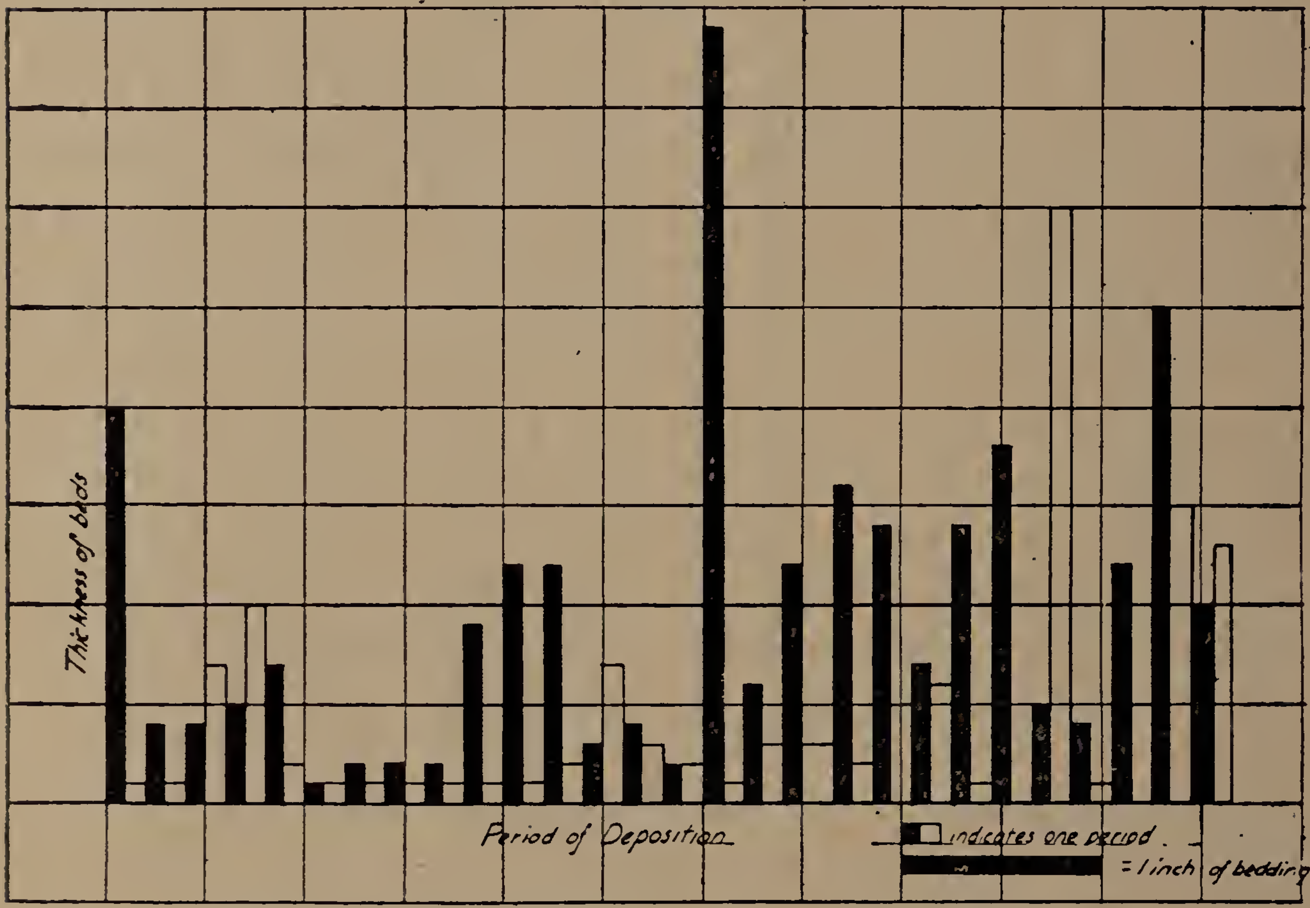

FIG. V. Rhythmic Banding, Oakland Road Ferry.

In the next case, when a twelve foot vertical section of rock shows as many as fifty bands it seems hardly possible that these are caused by a successive rise and fall of sea level. In this connection Graton speaking of the Witswatersrand says, "One might admit a moving beach as the cause of moving one mantle of pebbles but I could not tolerate such a means for a succession of horizons".[16] This applies equally well, in our own case where numbers of successive beds show such similar characteristics.

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[16] L. C. Gratan, *Economic Geology Supplement*, May 1930, p. 23.

After studying these possibilities and the rocks themselves we have finally come to the conclusion that the banding is due to seasonal change. We visualize a broad shallow sea receiving the drainage from a number of rivers. During the rainy season when the rivers are in flood coarser material was brought down and deposited while the finer silts remained in suspension. During the dry season when the volume of water was less, finer silts were brought down and deposited over the sands along with the material already in suspension. The width of each bed is thus determined by the length of a season. During a number of years this type of deposition leaves a good deal of scope for variation in relationships between the thickness of light and dark beds such as are shown in the sediments in the Park. These suggestions agree with those of the late Professor Barrell[17] who thought that, though rhythmic banding might be due to fluctuations of current at a river mouth, such regularity of occurrence suggested rather climatic change. This is, of course, quite rapid deposition; but here again the facts point to such a condition. It is thought that a high angle of inclination in cross-bedding indicates rapid deposition.[15] The angles which we have measured run as high as 23°. This is well above the general average for marine cross-bedding. Under the microscope it has been found that the grains show no very careful sorting either according to size or composition. This also suggests quick deposition. The adoption of this seasonal banding theory opens an interesting field of examination into the climatic record thus left and into the length of time taken for the deposition of a given depth of sediment.

Cross-bedding may be formed by:

1. Aggrading deltas.
2. Torrential alluvial fans.
3. Current ripples.
4. The action of wind on desert sands or exposed bars.

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[17] J. Barrel. *Bull. Geol. Soc. of Am.*, vol. 23, p. 425.

It is impossible that our cross-bedding is caused by an aggrading delta or an alluvial fan as these two types occur on a much larger scale, usually being measured in terms of feet. In successive layers the beds will slope in the same direction. As the sketches clearly show, that is not the case of those which we have been examining. Fig. VI.

G. K. Gilbert[18] describes cross-bedding of a type very similar to ours which he attributes to current ripple, as follows: "It appears that sediment may be added to a rippled surface without any disturbance of the pattern but there is usually a coincident shifting of the pattern in some direction. In order that sediment may be brought it is necessary that there be a general current in addition to the oscillation current caused by waves and it may be safely assumed that the shifting of the ripple pattern follows the direction of this general current. Just as the direction of the general current may make any angle or no angle with the direction of the oscillatory current so the direction toward which the pattern is shifted may bear any relation to the trend of the ripples. The shifting of the ripple profile during the accumulation of sediment makes the accumulation unequal on the two sides of the trough and if the ratio of shifting to deposition exceeds a certain amount there is deposition only on one side of the trough and erosion on the other. In each case an oblique structure or cross lamination results, and in the second case the general structure given to the sand mass includes two systems of oblique planes. One system is produced by deposition and laminae represent the successive positions of the concave ripple-profile. The other system is produced by erosion and its planes represent the progress of the profiles of the troughs along certain tangents. This structure may be called compound cross-bedding". This description applies equally well to our cross-bedding and may serve as an explanation of the way in which it has been formed.[19]

Grabau[20] does not agree with Gilbert but suggests that the cross-bedding with which he is dealing is aeolian. We have

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[18] G. K. Gilbert. *Bull. Geol. Soc. of Am.*, vol. 10, p. 139.

[19] See also E. M. Kindle, Can. Geol. Survey. Museum Bulletin 25.

[20] A. W. Grabau. Loc. cit., p. 705.

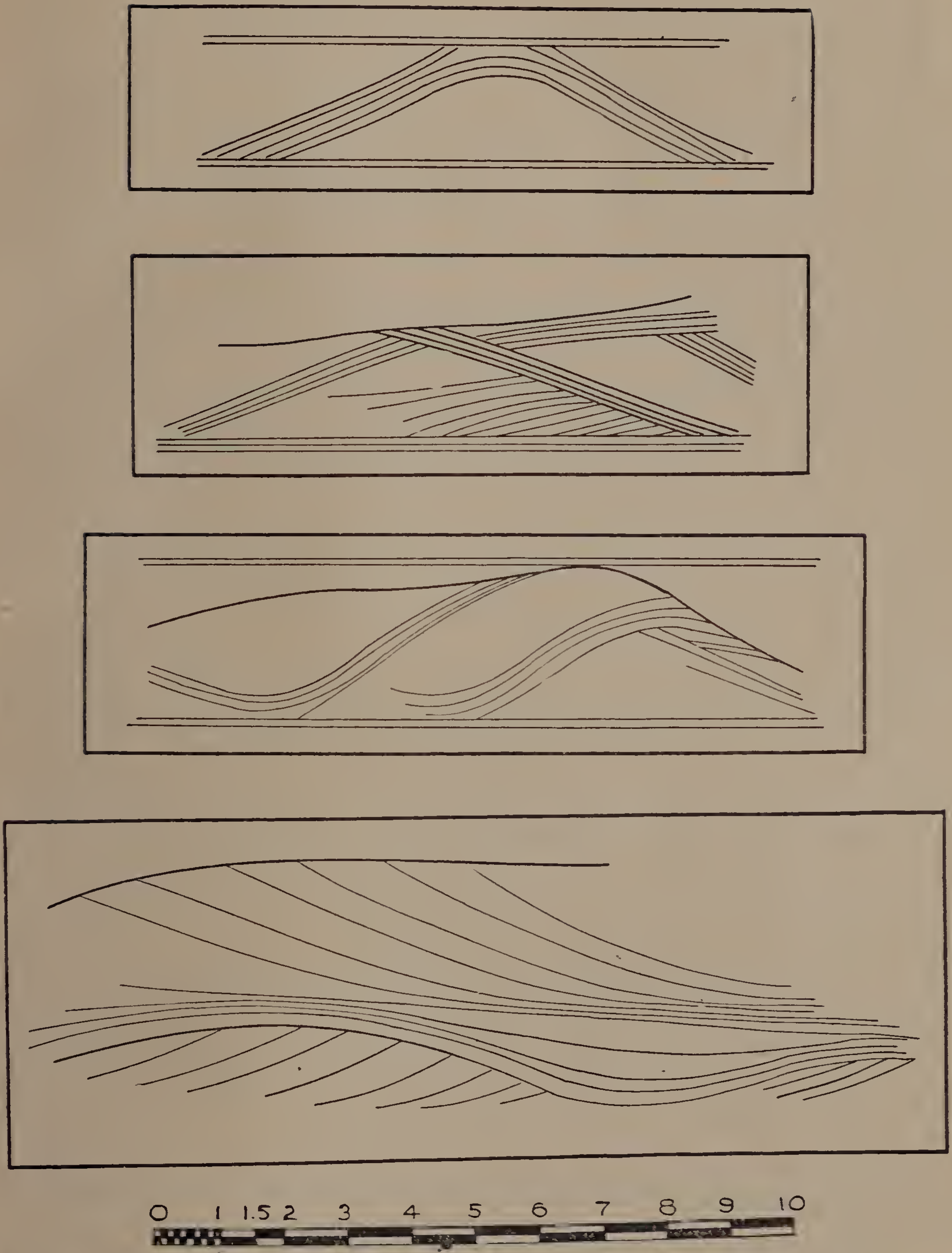

FIG. VI. Examples of a current-ripple type of cross-bedding from Point Pleasant Park with a centimeter scale.

considered this possibility in our own case, but have discarded it because, under the microscope, the grains showed no sign of the frosting and rounding typical of desert sands. No faceted pebbles common in aeolian deposits have been found. "Desert sands may be expected to contain abundant feldspar."[21] Sediment from the Park examined under the microscope shows little feldspar. In addition to these facts a sample of cross-bedded quartzite from Point Pleasant Park was sent to Dr. E. M. Kindle, Chief of the Division of Palaeontology of the Geological Survey of Canada, who stated that he considered it to be caused by currents, not by wind, as in the latter case the beds usually showed an inclination of 33°, whereas, as we have already mentioned, these do not exceed 23°. In support of this theory we find that Thorolf Vogt[22] describes a type of cross-bedded quartzites in the Scottish Highlands similar to ours which he attributes to current action. A type of current cross-bedding corresponding to ours in dimension and form is found in parts of the Dalradian succession[23] of sediments. The presence of fossil ripple marks on several faces of the rock seems to endorse the opinion that current ripple is the most probable cause. Therefore, taking all the evidence into consideration we have come to the conclusion that current ripple built up this cross-bedded structure.

In conclusion let us present the whole picture which we suggest as accounting for existing conditions. In Precambrian times these sediments were laid down in a broad shallow geosyncline. The material was brought down by rivers and deposited at a considerable distance from shore. The banding was caused by the seasonal variation in the size of grains of detritus deposited in this area. As the material was deposited, it was acted on by waves and current, developing a current ripple type of cross-bedding. The uniformity of condition was maintained by a gradual sinking of the sea floor.

[21] A. Harker. Loc. cit., p. 65.

[22] T. Vogt. Geol. Mag. Feb. 1930.

[23] Allison. Quarterly Journal Geol. Soc. of London. p. 125, April 1934.

ACKNOWLEDGEMENTS.

The work of this report was undertaken as a course in Geology at Dalhousie University under the direction of Professor G. Vibert Douglas whom the writers wish to thank for his constant assistance and advice. They also wish to acknowledge the assistance of Mr. Julius Forster and Mr. Claude Howse.

NOTE. A paper by F. P. Shepard, J. M. Trefethen, and G. V. Cohee in the Bull, Geol. Soc. of Am. for April, 1934 has come to our notice, but too late for discussion in this paper. Reference is made on p. 283 to the belief, supported by Warren Upham and D. W. Johnson, that there previously existed a land mass to the south-east of N. S. which accords with the theory developed in our paper.

THE EFFECT OF HISTAMINE, ADRENALINE AND DESTRUCTION OF THE SPINAL CORD ON THE OSMOTIC PRESSURE OF THE BLOOD IN THE SKATE.

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and
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(Received April 30, 1934).

ABSTRACT.

Preliminary experiments on the effect of histamine and adrenaline on the osmotic pressure of the blood of *Raja erinacea* showed a fall with histamine and no effect with adrenaline. Indications are that the histamine effect takes place through the loss of urea. This may occur either through an alteration in the permeability of the gills for urea or through an impairment of the reabsorption mechanism of the kidney. Both possibilities stand in need of experimental investigation. The effect of histamine on the blood plasma chlorides is uncertain. After ten hours the Cl values were below normal but after fifty-seven hours they were considerably above normal.

Introduction.

It is a well established fact that the blood concentration of the elasmobranchs is greater than the concentration of the sea water in which the animals are living. In a series of 14 *Raja erinacea* Chaisson[1] found the freezing point depression (△) of the blood to be 1.80±.01°C and the sea water △ to average 1.72°C. The greater freezing point depression of blood is due to the high urea content known to be present in elasmobranch body fluids which accounts for about half of the △ value (Smith[2]).

Chaisson[1] found that destruction of the greater part of the spinal cord of *Raja erinacea* results in an impairing of the mechanism which normally maintains the concentration of the blood above that of the sea water. Inasmuch as Scott and Denis[3] have shown that in the dogfish the only surface where interchange between external and internal media is possible is the gill membrane, it was presumed that the permeable properties of the gill membrane were altered either directly through the destruction of a nervous regulatory mechanism or, what was believed more probable, through shock and the liberation of a histamine-like substance causing increased permeability of the capillary walls.

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[1] Chaisson, A. F. *Proc. N. S. Instit. Sci.* **18**, 23-25, (1931).

[2] Smith, H. W. *J. Biol.. Chem.* **81**, 407-419, (1929).

[3] Scott and Denis. *Amer. J. Physiol.* **32**, 1-7, (1913).

During the summer of 1933 the opportunity was presented to continue this investigation at the Atlantic Biological Station, St. Andrew's, N. B. Besides the effect of destruction of the spinal cord, the effects of histamine and of adrenaline on the blood concentration were studied.

METHODS.

The animals, *Raja erinacea*, were used after at least three days had elapsed from the time trawled, as MacKay[4] and our own observations show that recently caught skates do not respond at all well to drugs. Throughout the experiment they were kept in tanks of running sea water, the Cl content and △ of which were determined at intervals. Some animals were injected with either adrenaline or histamine, others had their spinal cord destroyed. Adrenaline (1 cc. of 1:10,000 to 10 cc. of 1:1,000) and histamine (0.5 to 20 mg.) were injected subcutaneously. (It is worthy of note that MacKay[4] found that histamine had no effect on the circulation of the skate when given intravenously and no local effect when given subcutaneously. However, our determinations were made at least seven hours after injection and so there can be no true comparison with her relatively much shorter time intervals). Destruction of the cord was carried out by passing a long wire needle down the neural canal from just below the medulla to the region of the anus. The skin at the point of insertion of the needle was then sewn watertight. The brain and medulla were not injured; this was noted from the fact that in these operated animals the respiratory and heart rates were good even at the end of 16 days, whereas injury to the medulla leads to almost immediate respiratory cessation.[5]

Gastric juice samples were obtained by aspiration. Blood for chloride and △ determinations was obtained as described by Chaisson[1]; a small glass cannula was ligated into the conus arteriosus and the blood was propelled into a test tube by the force of the heart beat.

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[4] MacKay, M. E. *Contr. Can. Biol.* Fish. 7, 17-29, (1931).

[5] Babkin and M'Gonigle. *Contr. Can. Biol.* Fish. 6, 315-339, (1931).

RESULTS.

Cord Destroyed. After the first or second day of the operation large amounts of gastric juice of a high acidity (pH 2.0 to 3.8) could be obtained: for example, animal No. 37 yielded a total of 68 cc. in 5 days. That the fluid aspirated from the stomach was gastric juice and not sea water is evident from the low pH and the difference in the △s of the sea water and stomach fluid.

The blood △ fell progressively from the normal △ 1.800°C. to an average △ of 1.665°C.; in animal No. 18 it was found to be as low as 1.515°C. nine days after the destruction of the cord. The blood plasma chloride values remained practically unaltered.

Adrenaline. As with animals whose spinal cords had been destroyed, skates that had been given adrenaline were found to contain large volumes of fluid in the stomach. This fluid, however, was probably not the result of gastric secretion but merely sea water that had entered the stomach due to the paralytic dilatation of the cardiac sphincter by the adrenaline. Both pH and △ values of the fluid are those of sea water.

The blood plasma chloride and blood △ remained unchanged even after prolonged and repeated administration of tremendous doses of adrenaline.

Histamine. The influence of histamine on gastric secretion in the skate is not noticeable. Its influence on the blood concentration, however, is marked; it causes a fall in the blood △ to an average of △ 1.660°C. with △ 1.423°C. as the lowest value recorded. The effect on the blood plasma chlorides is uncertain: at the end of 10 hours the Cl values were found to be all below the normal, and averaged 0.83%, whereas at the end of fifty-seven hours the Cl values were very much above normal, and averaged 0.99%.

Table 1 summarizes the above results. It should be added that though in the normal skate there is a continuous secretion of acid gastric juice, in the starving animal, the amount secreted is very small and does not permit of analyses.[6]

Table 1

Experiment	Gastric Contents		Blood Plasma	Whole Blood	Sea Water		
	pH	Δ °C.	Cl%	Δ °C.	pH	Cl%	Δ °C.
Normal Animal	—	—	0.91	1.800	8.2	1.80	1.720
Cord Destroyed	3.1	1.497	0.93	1.665	—	—	—
Adrenaline	7.6	1.719	0.92	1.798	—	—	—
Histamine	—	—	0.83 to 0.99	1.660	—	—	—

DISCUSSION.

Our investigation confirms previous evidence that the osmotic pressure of the skate's blood is diminished when the spinal cord is destroyed. We found also that it falls when histamine is injected but is not affected by adrenaline. It is conceivable that the fall in the osmotic pressure of the blood is due to loss of the inorganic constituents, chiefly of the chlorides which make up the greatest part of the mineral compounds of the blood. However, after destruction of the cord the blood plasma chlorides remain unaffected and histamine diminishes them only in the first hours following its administration but later on they return to, or even exceed, their initial value. No definite explanation of this observation can be given but it is possible that the variations in the Cl values were partly due to a shifting of the Cl from plasma to corpuscles. Therefore it seems more probable that the lowering of the osmotic pressure of the blood in these cases is due to a loss of urea, a substance which normally is responsible for about half of the blood Δ value.

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[6] Babkin and Friedman. *Amer. J. Physiol.* **109**, 3, (1934).

The question arises, by what path is the urea eliminated from the body? Nothing is known about the excretory capacity of the skin and skin glands in the skate. According to Smith[7], "the gills of elasmobranch fishes are relatively impermeable to urea, and in addition, the kidneys of these animals conserve this substance by reabsorbing it from the glomerular filtrate." But Babkin and Komarov[8] have shown that the gastric mucosa excretes urea in concentrations up to 1%. It is not known if the intestinal mucosa has the same property. Since histamine does not activate a gastric secretion it is improbable that the urea is lost through the gastric mucosa. Again, the animals could not be regarded as starving. One of two hypotheses would explain the histamine effect: either the permeability of the gills is altered by histamine and urea can be passed through them or else the reabsorption mechanism of the kidney for urea is impaired. Both of these suppositions require experimental investigation. In the case of the destruction of the spinal cord, the lowering of the blood $\triangle$ may also be explained by a functional impairment of either the gills or the kidney. However, since the destruction of the cord results in a "paralytic" gastric secretion which often is very profuse[6], a part of the blood urea may be excreted with this secretion.

Judging from the fact that adrenaline does not influence the osmotic pressure of the skates' blood, it is probable that it does not affect the reabsorption powers of the kidney nor, under the conditions of our experiments, does it alter the permeability of the gill membrane. The results do not support the supposition made by Keys and Bateman[9] that adrenaline increases the permeability of the elasmobranch gill.

We wish to express our deep appreciation to Prof. B. P. Babkin for his interest in and criticism of the problem, and our thanks to the Biological Board of Canada for the facilities afforded.

[7] Smith, H. W. *Sigma Xi Quart.* **21**, 141-151, (1933).

[8] Babkin and Komarov. *Contr. Can. Biol.* Fish. **7**, 13-15, (1931).

[9] Keys and Bateman. *Biol. Bull.* **63**, 327-336, (1932).

MONSTROSITIES IN SALMON EMBRYOS.

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(Received May 21, 1934).

ABSTRACT.

Twelve abnormal salmon embryos were examined alive as well as in serial sections. They showed three types of monstrosity: (1) a tendency to form twins; (2) cyclopean abnormalities of the eyes; (3) unnatural relations of the embryo to yolk sac. Twenty illustrations are contained in the contribution; fourteen sketches of various embryos and six photomicrographs of serial sections.

The following provisional generalizations are made: (1) in double embryos in which union takes place posterior to the head, the ventral structures become united before the dorsal ones; (2) in double embryos in which union takes place in the head, the dorsal structures become joined earlier than the ventral ones; (3) in double embryos the duplication of the fins and tail may persist posteriorly beyond the point of union of the trunks; (4) the internal organs of partial twins are frequently mirror images.

INTRODUCTION.

At all times the occurrence of monsters has aroused a great deal of curiosity, and various investigators from Aristotle downwards have used teratological data in the derivation of certain principles in embryology. The result has been an abundance of descriptive reports upon this subject. However, information concerning monsters in fishes has been compiled only very slowly and this paper describes a study of a small group which was found recently. This type of work involves an attempt to observe the guiding principles which govern abnormal development. We know that very definite laws operate in normal embryology, but the question arises as to whether any such definite laws operate in abnormal embryology.

By way of approach to the subject, it will be to advantage to discuss briefly the available literature. At various stages in their careers Cuvier, Rauber, von Baer, Spemann, Loeb and Morgan have prepared contributions to this branch of biology. In the twentieth century, however, the field has been broadened and consolidated most of all by the work of Gemmill and Stockard. To Gemmill we are indebted for a series of morphological studies [1-2] as well as an excellent monograph[3]; to Stockard[4-5] for physiological and experimental investigations.

Gemmill's monograph, which deals with the structural aspect of abnormalities in fishes, is a complete summary of the literature previous to 1912. The work is especially valuable in referring to general topics such as the classification of monsters and their occurrence, causation and development.

Stockard[4-5] opened up a new line of investigation by the artificial production of monstrosities due to the environmental adjustments of certain teleost embryos. His "magnesium embryos" which exhibited cyclopia with astonishing regularity were raised in a medium of excess magnesium chloride. Some years later Stockard[5] was able to produce a high ratio of double monsters in trout by altering the developmental rate at a very early stage. These results indicate that monsters in nature do not arise only as spontaneous germinal variations, as was hitherto supposed, but that the environment is a factor to be considered.

THE ABNORMAL EMBRYOS.

The abnormal specimens of *Salmo salar* used in this investigation were obtained from a small hatchery in the Dalhousie Zoology Laboratory. Its capacity was five thousand eggs. The eggs had been transferred from the Dominion Government Hatchery at Bedford, N. S., in November, 1932. This piece of work was carried out during February, 1933, some two weeks after hatching had commenced. Sketches were made of the living embryos. Then the embryos were fixed in Bouin's picro-formol and serial sections were prepared at a later date. The results of the investigation will be presented for the most part in pictorial form as a series of sketches of the embryos and photomicrographs of certain serial sections.

[1] Gemmill, J. F. *London Proc. Zool. Soc.* 1903 (4-23).

[2] Gemmill, J. F. *London Proc. Roy. Soc.* 68, No. 444 (129-131), 1901.

[3] Gemmill, J. F. *The Teratology of Fishes*—Glasgow—James Maclehose, **1912**

[4] Stockard, C. R. *Jour. Exp. Zoo.*, Vol. VI, No. 2, 1909.

[5] Stockard, C. R. *Amer. Journ. Anat.*, 28, No. 2, Jan. 1921.

Figures I and II picture the state of affairs in the normal salmon embryo at an age corresponding to that of the monsters. The main points of the internal and external anatomy are indicated, and these figures should be compared with the sketches of the various abnormal embryos.

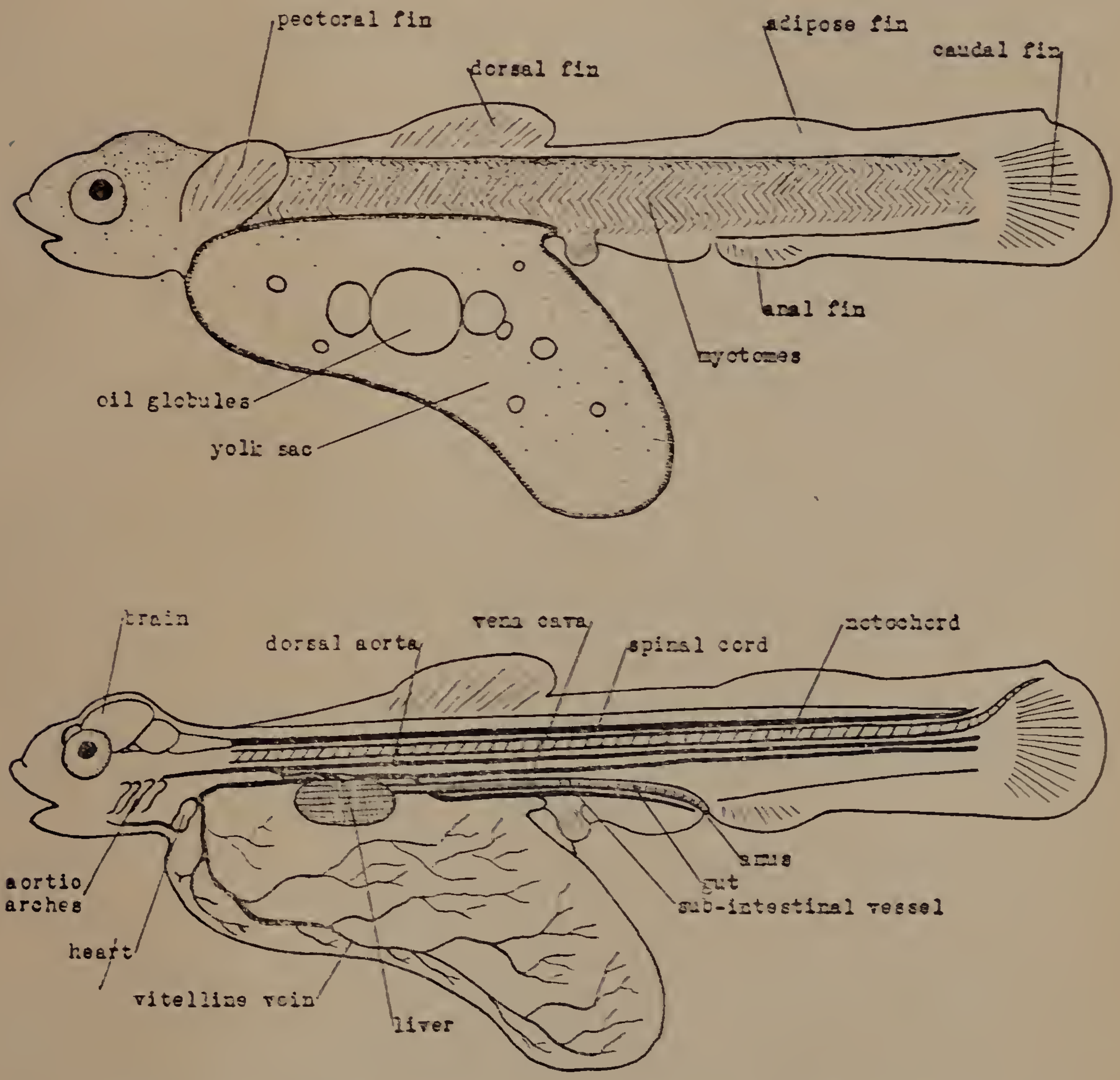
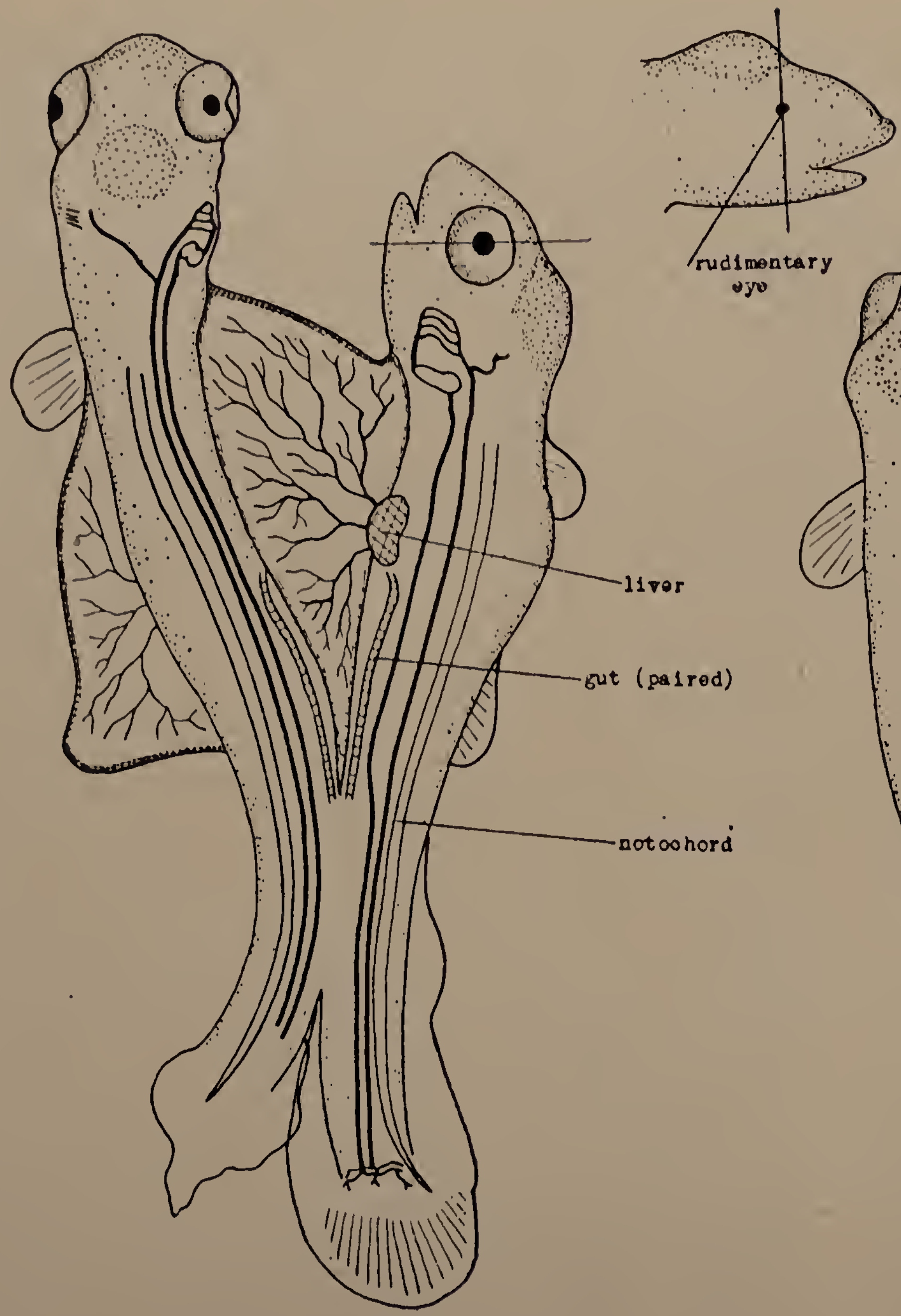


FIG. I. and FIG. II. Normal Salmon Embryo. External and Internal Anatomy.

Three types of abnormality occurred within the group of twelve specimens studied. There were (1) eight double monsters, (2) one cyclopean monster, although two of the twin embryos possessed cyclopean tendencies as well, and (3) three embryos which were attached to the yolk sac in an unnatural manner.



FIG; III.

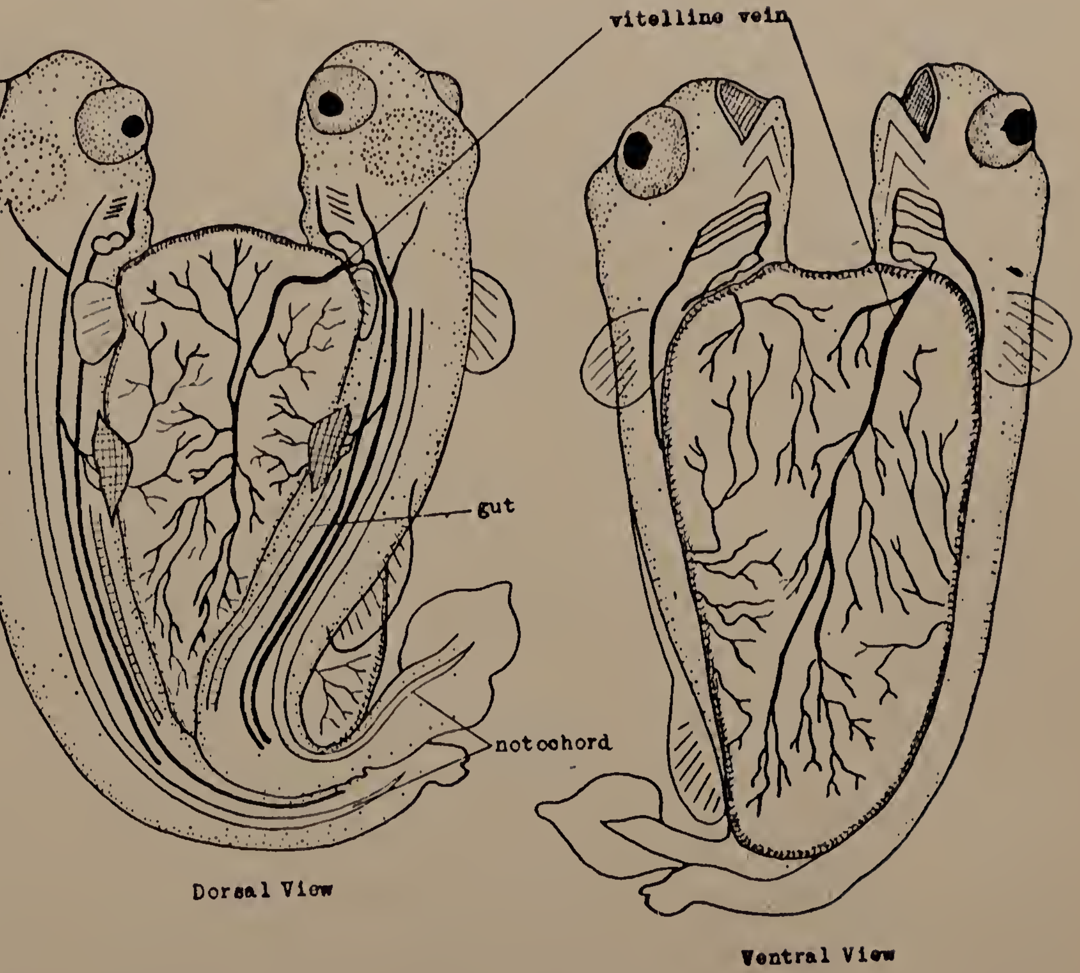


FIG IV.

DOUBLE MONSTERS.

The double embryos exhibit various degrees of duplicity. In Fig. III is shown a specimen in which the two members are almost completely separated. There is doubling in both the anterior and posterior regions. This type is extremely rare, Gemmill[6] finding none in a group of three hundred abnormal trout embryos. One of the members possesses a defective eye and it will be referred to later. It is worthy of notice that in the single portion of this embryo, the double ventral structures, such as the twin guts, lie nearer to each other than the dorsal structures, such as the twin notochords. This tendency may be observed in many other cases of twinning and it is called the principle of ventral convergence. Another anomaly which this specimen presents is that the tail of the left hand member is quite defective. This is a common occurrence in embryos of this type, and in Fig. IV, a second case of anterior and posterior doubling is shown in which both tails are poorly developed. Ventral convergence can be seen in operation in this specimen. It will be noticed that in one member both the heart and the liver are situated to the right, while in the other member both these organs are to the left. Now in a normal embryo of this age, the heart is to the left and the liver to the right. Thus in a double monster there seems to be a tendency to change this situation and the result is that the internal organs in one twin are the mirror images of those in the other.

The embryo illustrated in Fig V has its point of union in its trunk and it ends in a normal symmetrical tail. The junction is approximately midway between the head and tail ends and both the principles of ventral convergence and of mirror images may be noted. The symmetry exhibited by the specimen is very rare, particularly in the region of the tail. Fig. VI shows an embryo with union at the same point, but it is notable that duplicity persists in the caudal fins so that a triangular tail is formed. The left hand member was being attacked by disease which caused the loss of its head.

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[6] Gemmill, J. F. *Teratology of Fishes*, p. 24.

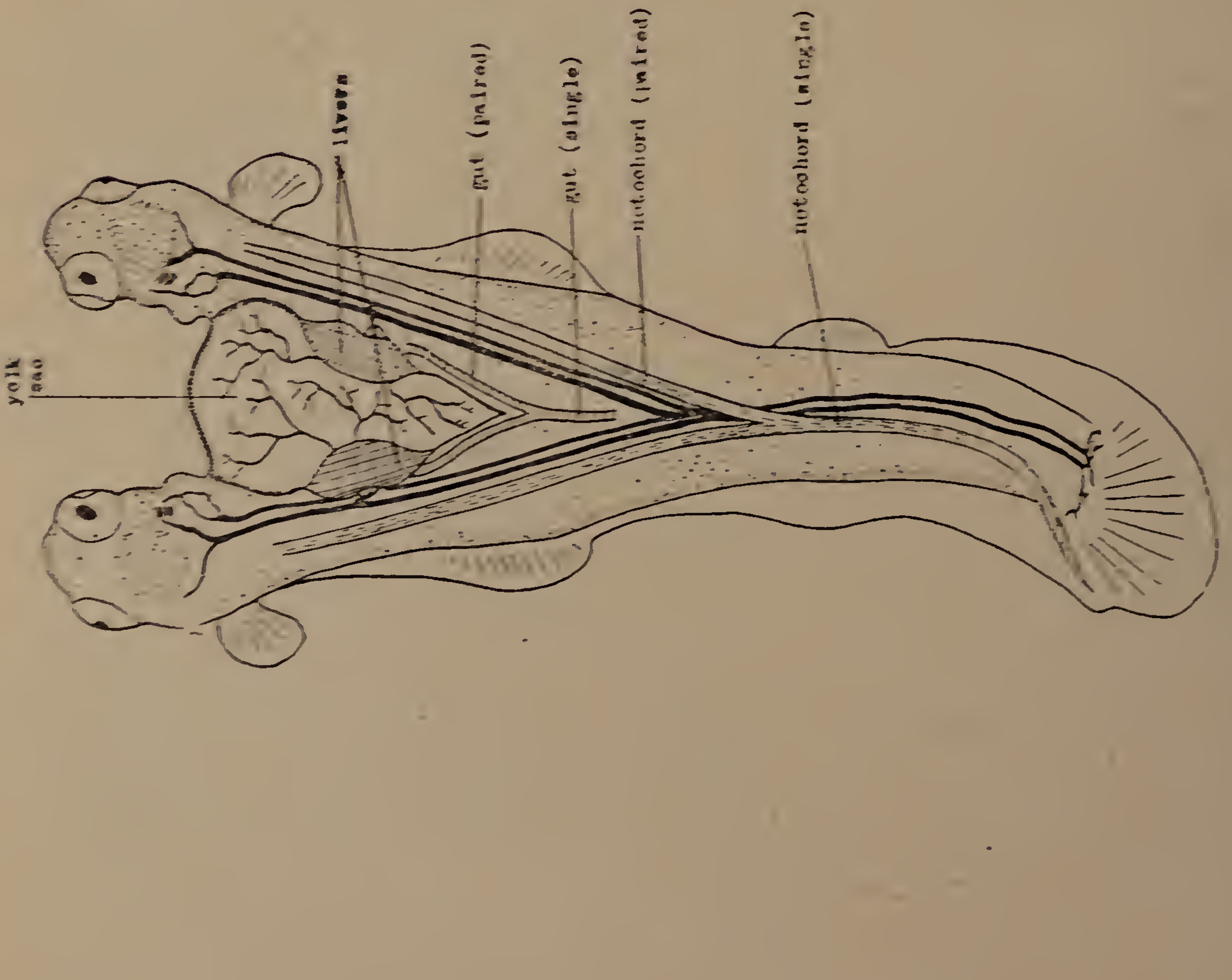
yolk sac
livers
gut (paired)
gut (single)
notochord (paired)
notochord (single)

FIG. V.

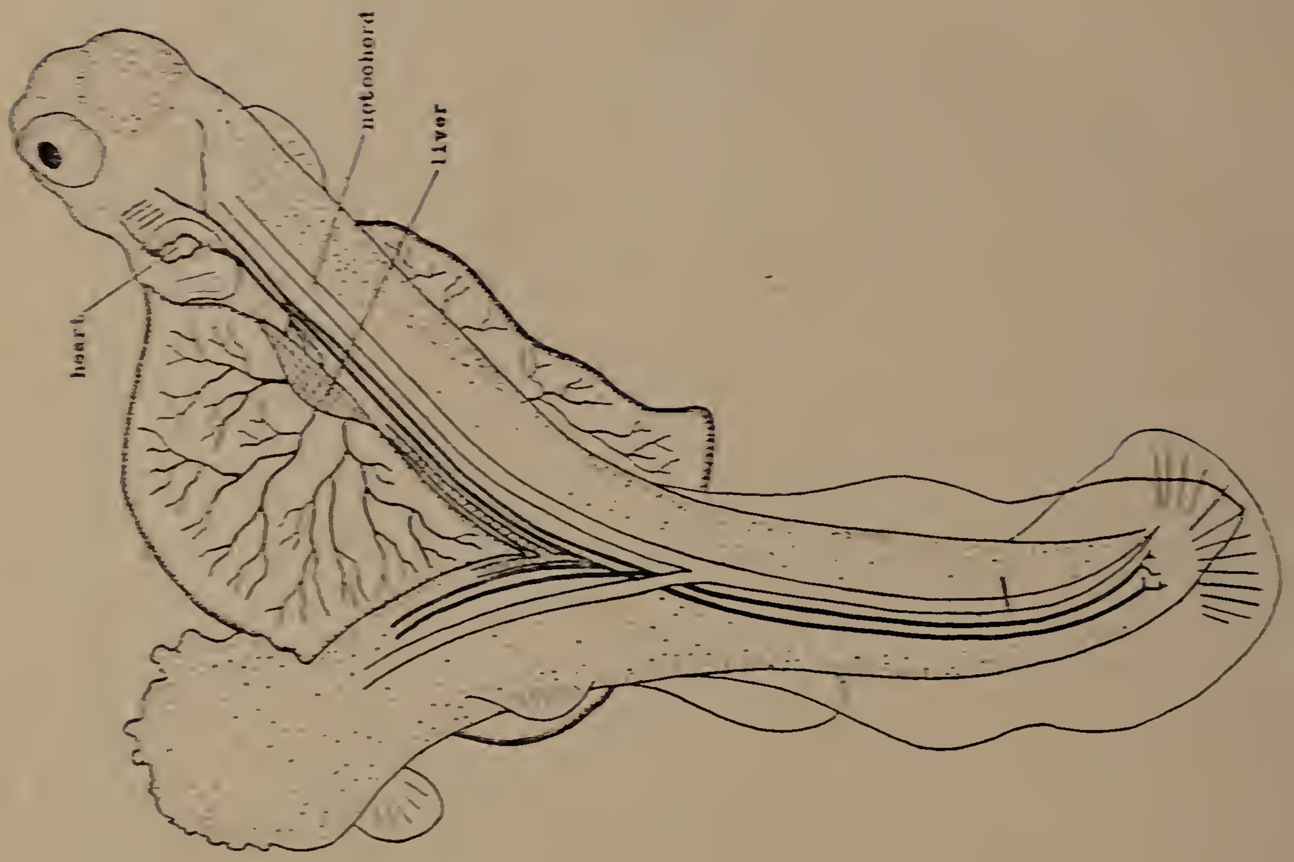
heart
notochord
liver

FIG. VI.

The growth of a fungus upon it showed that it was not due to under-development such as occurs in the two specimens to follow.

In Figs. VII and VIII embryos are illustrated in which the union takes place in the trunk region but in each case the development of one of the members is lagging behind the other. All the structures of the defective member are more or less distorted and the sections show that some structures, e. g., the notochord and the spinal cord, are missing. It is interesting also that the fins possess a double structure posterior to the point of union, and that the caudal fins are quadrangular in each specimen.

One double monster was found in which the union takes place in the pectoral region. The head of the left member is very poorly developed, no eyes being present. The two heads are very closely associated and, as Fig IX shows, a partial union occurs in the region of the gill arches. Thus the development of certain adjacent structures, e.g., the pectoral fins, has been arrested. The two hearts are partially joined and by reference to the figure it will be seen that there are two auricles but only one ventricle. The ventral aorta is common for a short distance but a complete set of aortic arches is present in each member.

In spite of this partial union in the head region, a second separation occurs and it is only far back in the body that the doubling is eradicated. A photomicrograph of a section (the position is indicated by the horizontal line through the animal in Fig. IX) is shown in Fig. XV. It will be seen that the double notochord persists although all the other structures are single. The spinal cord, however, has a triangular outline unlike the circular shape it possesses in a normal embryo, indicating that the two portions have fused a very short distance in front. This tendency for the duplicity of the notochord to persist farther than that of any other structure has been noticed by other investigators[7]. The general principle of ventral convergence, insofar as the ventral structures

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[7] Gemmill, J. F. *The Teratology of Fishes*, p. 19.

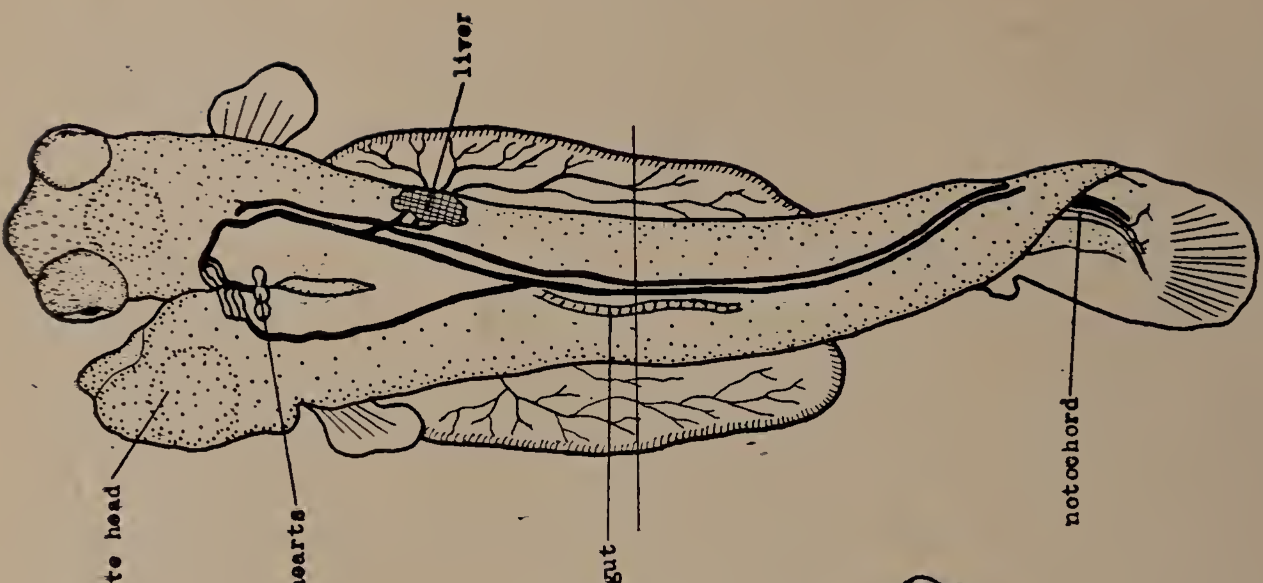

FIG. IX.

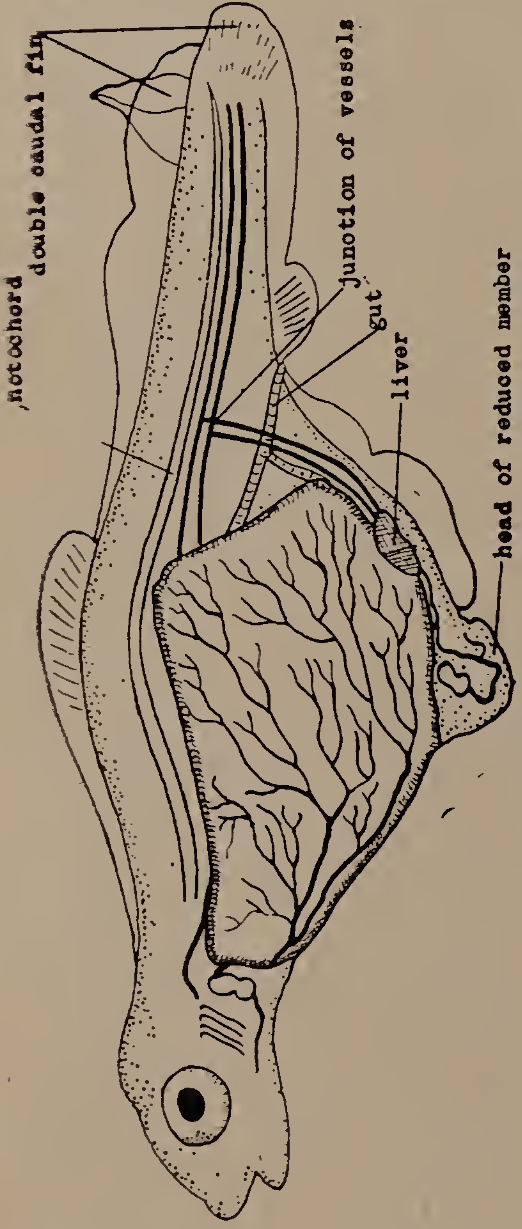

FIG. VII.

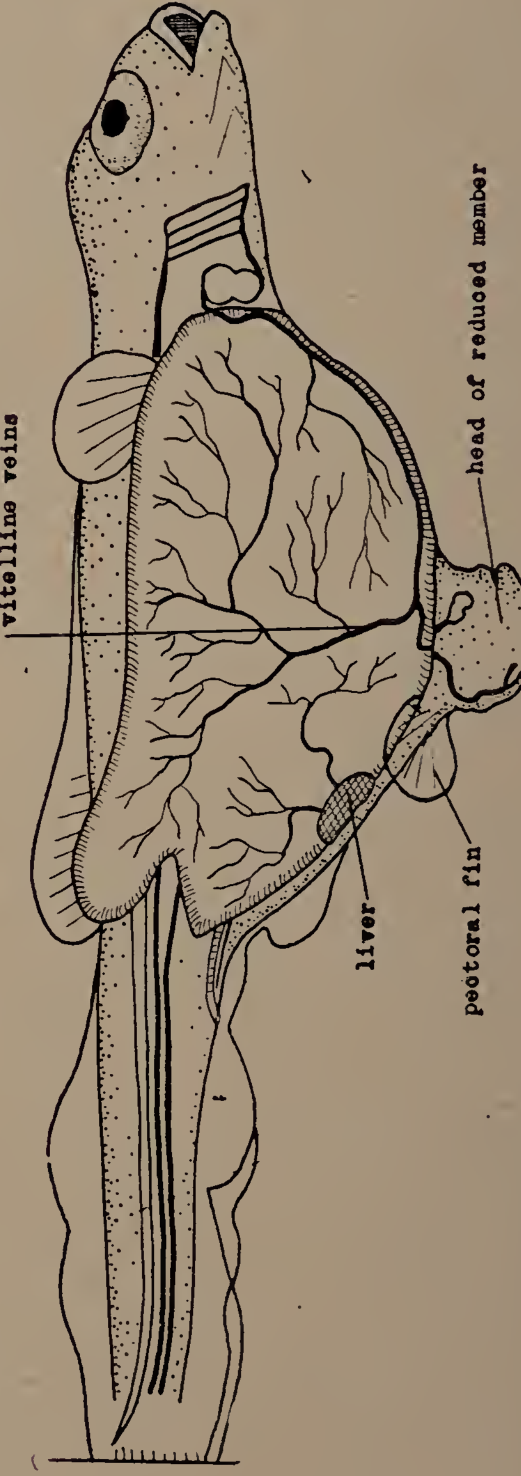

FIG. VIII.

become joined first, is borne out by this as well as the other specimens.

Fig. X. illustrates a double-headed monster with union in the region of the optic lobes of the brain. Externally the embryo appears to be single, but the sections point out that it is in reality a case of partial twinning. The large median eye consists of two eyes, one from each head, which have come to lie very close together (Fig. XVIII.) On the right a smaller eye appears which has no mate on the left side. The twin mouths are very noticeable, both externally and when observed in the sections, but most of the other doubled structures are obscured, especially in the more posterior parts of the head.

The actual state of affairs in this embryo is best shown by the series of photomicrographs, Fig. XVI, XVII and XVIII. The positions of these sections are indicated by the vertical lines through the animal in Fig X.

Fig. XVIII shows very clearly the double structure of the median eye and each of these adjacent eyes seems to be almost complete, lens and retina both being present. A section (not illustrated) through the posterior part of this eye shows that two sets of cerebral lobes lie very close together. A more posterior view (Fig. XVII) pictures the actual elimination of duplicity in the brain. In fact, it is seen to be single in its dorsal structures but double in its ventral ones, since there is but one set of optic lobes, but a third ventricle on each of the two ventro-lateral positions. A section still more posterior shows that the brains become completely joined. However, the important point in a double monster of this kind seems to be that the union of the dorsal structures occurs in front of the union of the ventral structures.

A section through the pectoral region of the same embryo may be seen in Fig. XVI. The double notochord is the outstanding feature, and it indicates that duplicity may occur again, even after a complete union in this case and after a partial union as in the specimen shown in Fig. IX. The spinal cord is single but its triangular outline, as opposed to the normal circular outline, indicates that there is a tendency

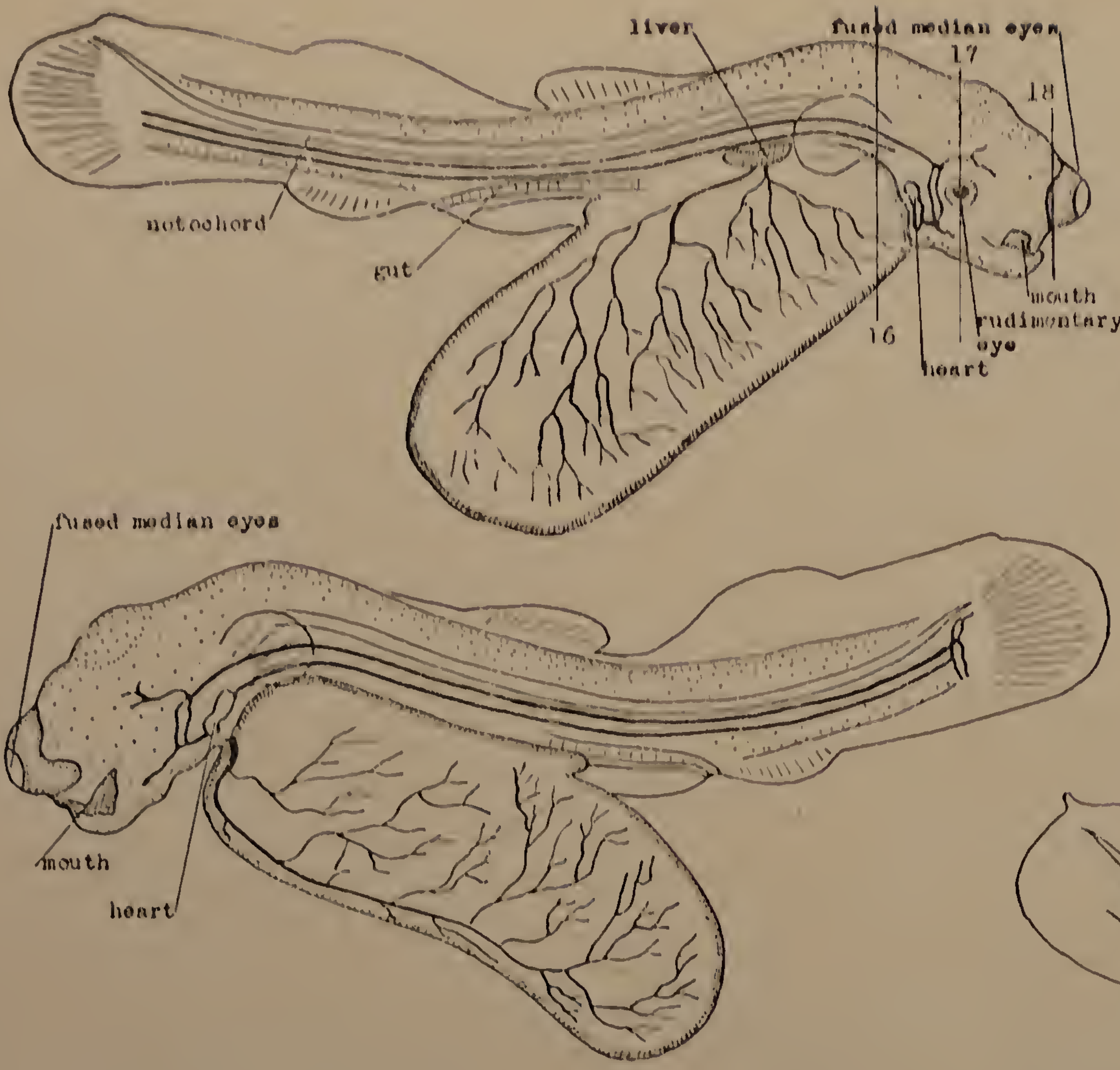
liver
fused median eyes
17
18
notochord
gut
16
mouth
rudimentary eye
heart
fused median eyes
mouth
heart

FIG. X.

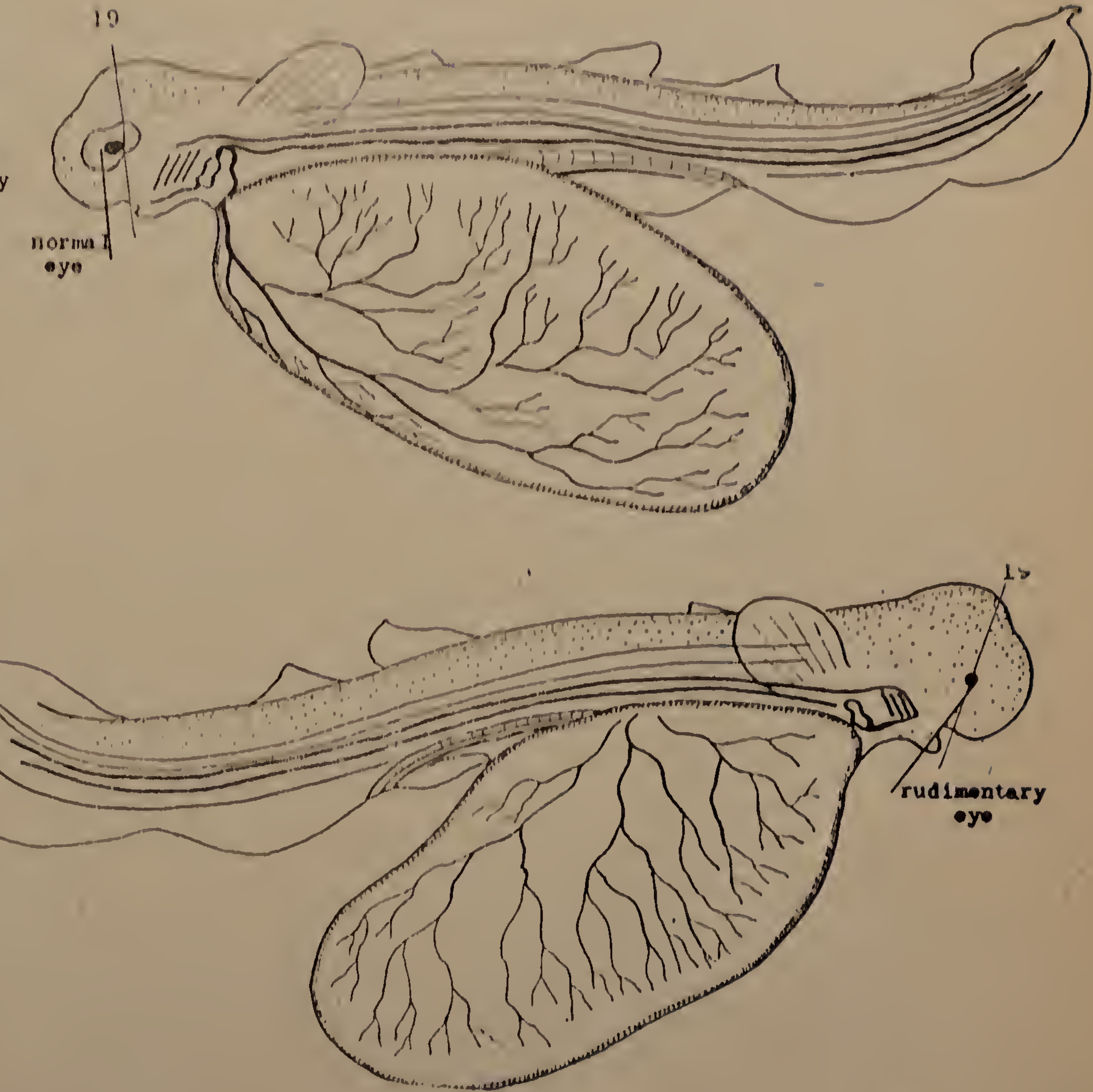
19
normal eye
15
rudimentary eye

FIG. XI.

towards duplication. Gemmill[8] has found monsters of this class in which the spinal cord is single at its anterior end but doubled a few segments back. The same tendency is evidently operating here, but it has not resulted in complete separation, but in a distorted spinal cord.

CYCLOPEAN MONSTERS.

The second group of monsters which will be discussed exhibited the phenomenon of cyclopia, a tendency towards the possession of one eye rather than two. It is not so fundamental a peculiarity as twinning. Stockard[9-10] has shown that an artificial cyclopean embryo may be produced by altering the conditions of development at a much later stage than the latest stage necessary for producing an artificial twin. The concensus of opinion seems to be that cyclopia is not so much a germinal as a somatic variation.

Cyclopia is exhibited by the embryos illustrated in Figs. III, X and XI. In Fig. XI is seen the only single specimen to possess the defect and a section through the rudimentary eye is shown in Fig. XIX. This embryo appeared rather unhealthy, and in fact it was very close to death when sketched. Fig. XIX shows the right eye as a group of pigmented cells with no trace of any nervous associations with the brain.

A section through the double monster in Fig. III cut as to show the rudimentary eye, is illustrated in Fig. XX. Its structure is almost identical with that of the eye seen in Fig. XIX. It is interesting that the defects of the eye in this embryo are associated with other defects in the brain, the two cerebral lobes having fused to form a single lobe. This condition was noted by Gemmill[11] in his series of cyclopean trout embryos.

In Fig. XVII, a third example of cyclopia may be viewed in a section from the embryo shown in Fig. X. In this case

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[8] Gemmill, J. F. *The Teratology of Fishes*, p. 14.

[9] Stockard, C. R. *Jour. Exptl. Zool.* Vol. VI, No. 2, p. 291, 1909.

[10] Stockard, C. R. *Amer. Journ. Anat.*, 28, No. 2, 132 and 152, 1921.

[11] Gemmill, J. F. *The Teratology of Fishes*, 40.

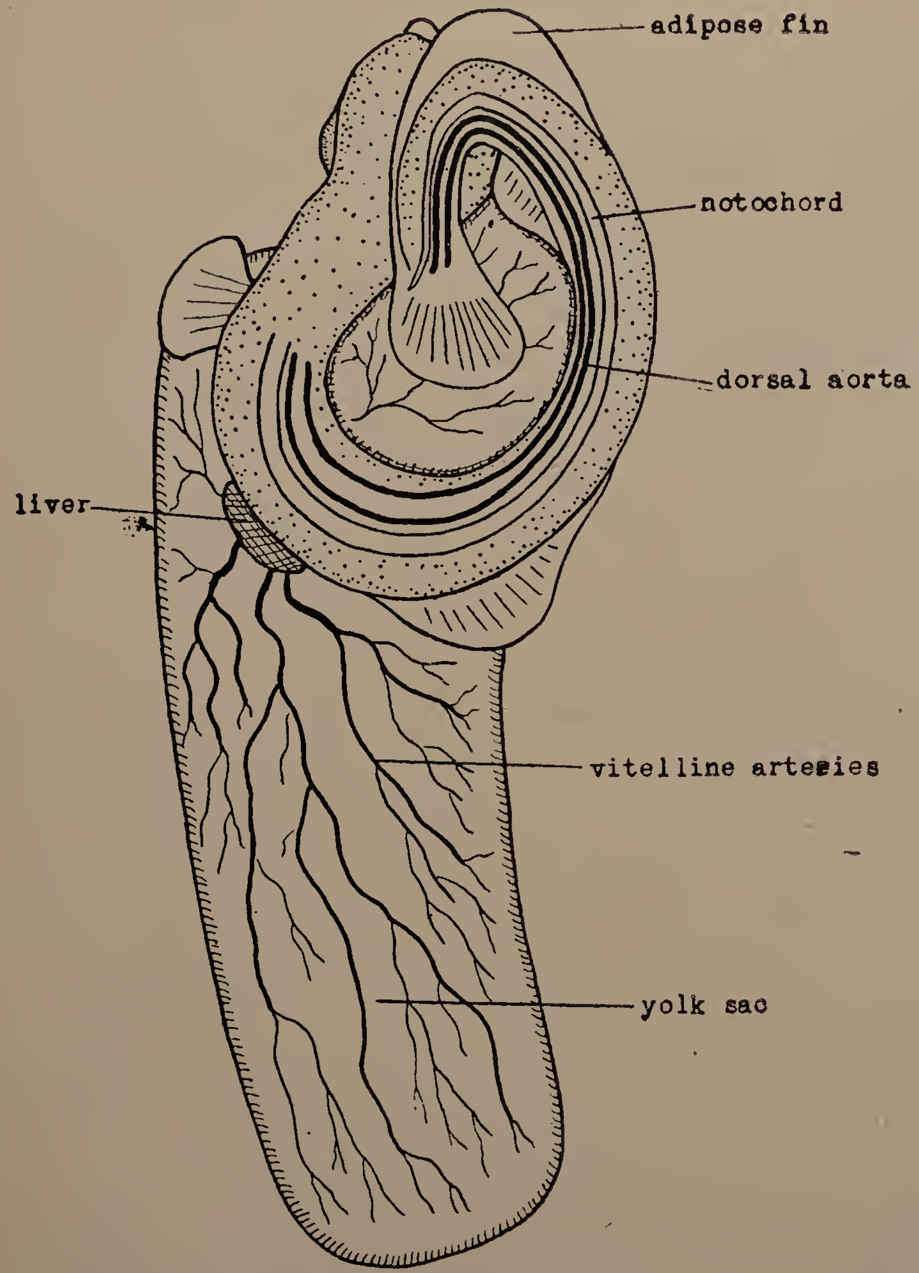

FIG. XII.

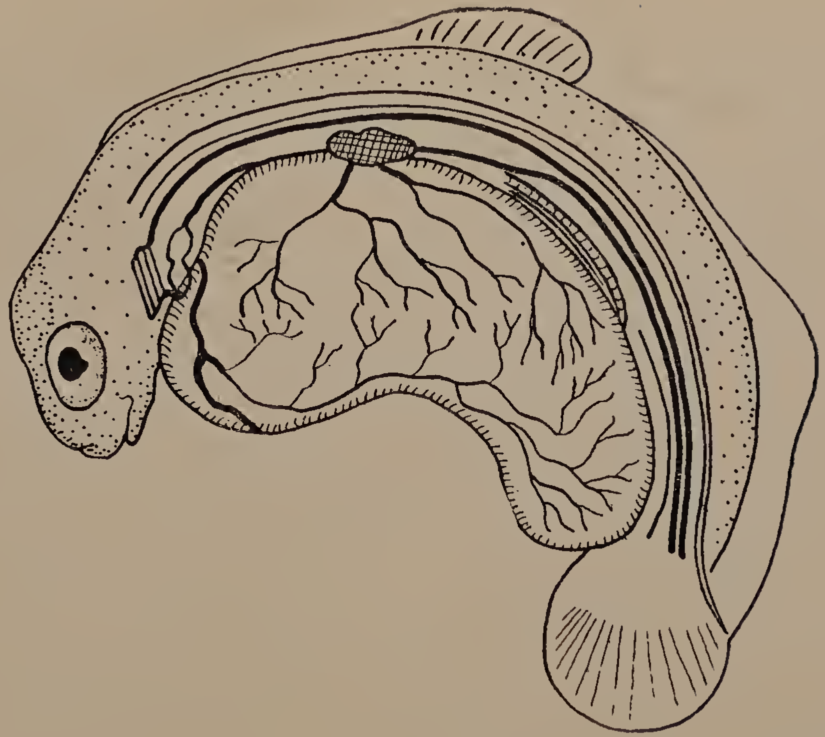

FIG. XIV.

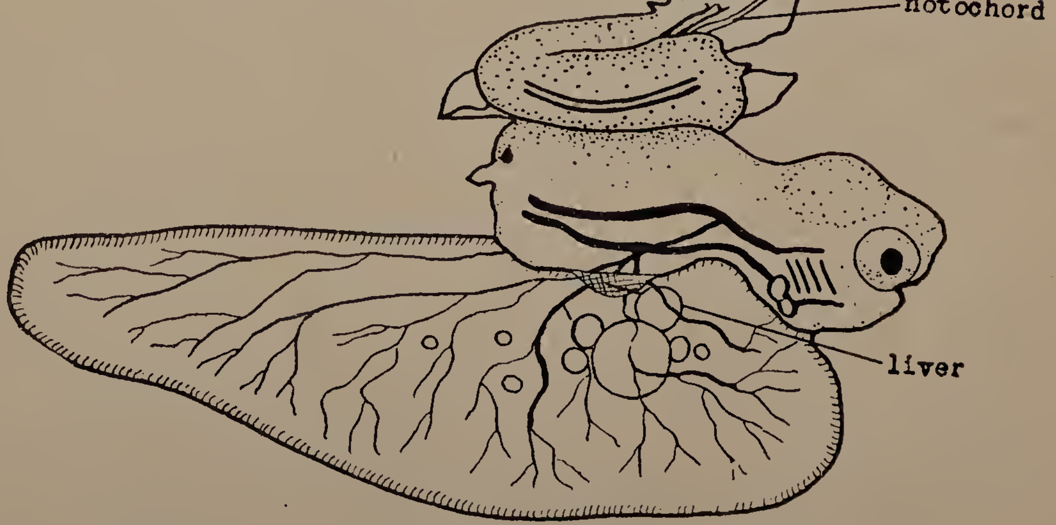

FIG. XIII.

the smaller eye is almost structurally complete although an optic stalk could not be detected in section. The same figure shows a group of cells on the other side of the head which possesses the essential features of an eye rudiment. A thorough study of a series of such eye rudiments should be of the greatest value in a study of the development of the eye and it would be interesting to compare the results of such an investigation with the accepted theories.

Abnormalities of Attachment to the Yolk Sac.

There remains one more group of abnormalities to be discussed, that of unnatural relations of the embryo with the yolk sac. On the whole, it is a minor type of monstrosity due in part to unusual physical conditions affecting the embryo while still contained within its egg envelope.

In Figs. XII and XIII embryos are shown which have become coiled. Some factors have caused them to grow thus within the egg and evidently they never recover. Since they cannot swim, this abnormality would operate against their survival in nature. Fig. XIV shows an embryo which is attached along its whole length to the yolk sac, a condition which should be compared with the normal attachment shown in Figs. I and II. Inasmuch as such conditions do not affect the fundamental organization of the embryo, they are of only passing importance and of little value for the derivation of principles.

Discussion and Conclusions.

The scope of the conclusions from a piece of work of this kind is limited very much by the small number of specimens studied. However, the group of eight double monsters were fairly generally distributed amongst the various classes and representatives of the most important types were present.

From the evidence presented, a few provisional generalizations with respect to double monstrosities may be drawn up and the following tendencies, may be said to have been observed:

(1) There is a tendency to ventral convergence in double embryos in which the union takes place posterior to the pectoral region.

(2) There is a tendency to dorsal convergence in double embryos in which the union takes place anterior to the pectoral region.

(3) There is a tendency in partial twins towards the persistence of duplicity in the fins far posterior to the point of union of the trunks.

(4) There is a tendency in partial twins causing the internal organs in one member to be the mirror images of the corresponding organs in the other member.

These generalizations follow from the specimens observed and they are in agreement with many observations made by various investigators not only upon fishes, but in other groups as well. However, further investigation may restrict their application to particular classes of double monsters only.

The writer wishes to acknowledge his indebtedness to Dr. F. R. Hayes who suggested and directed the work, and to Dr. Dixie Pelluet, whose criticisms and suggestions have been invaluable.

Lettering in Figs. XV-XX.

er.	Eye Rudiment.
int.	Intestine.
l.	Lens.
nc.	Notochord.
ne.	Normal Eye.
ol.	Optic Lobes.
re.	Rudimentary Eye.
rt.	Retina.
sc.	Spinal Cord.
v3.	3rd ventricle.

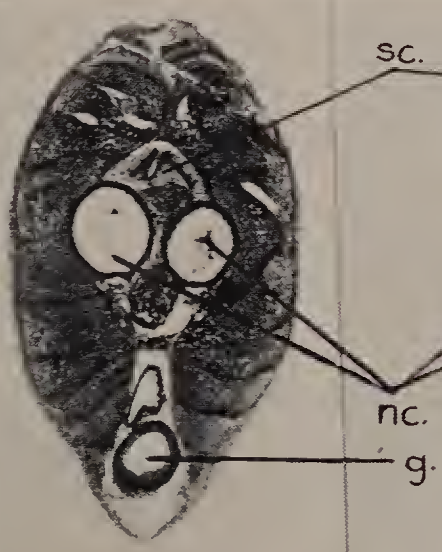

Fig. XV

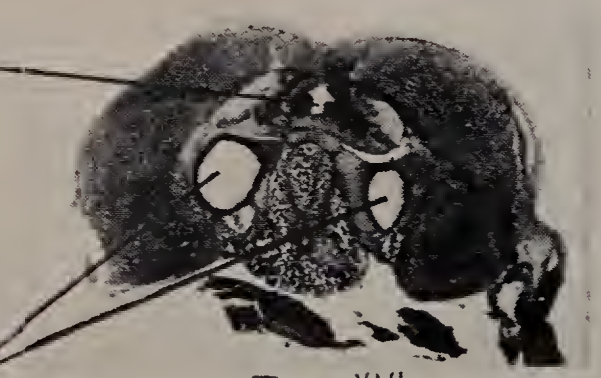

Fig. XVI

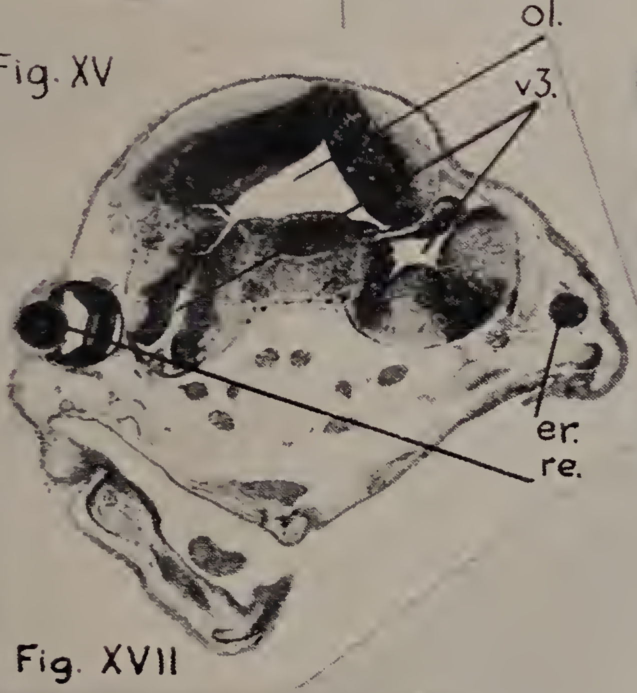

Fig. XVII

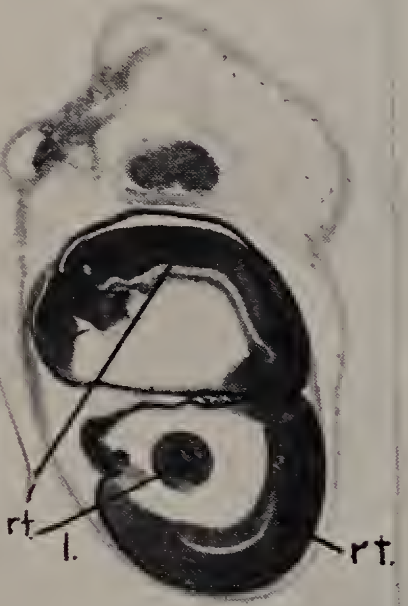

Fig. XVIII

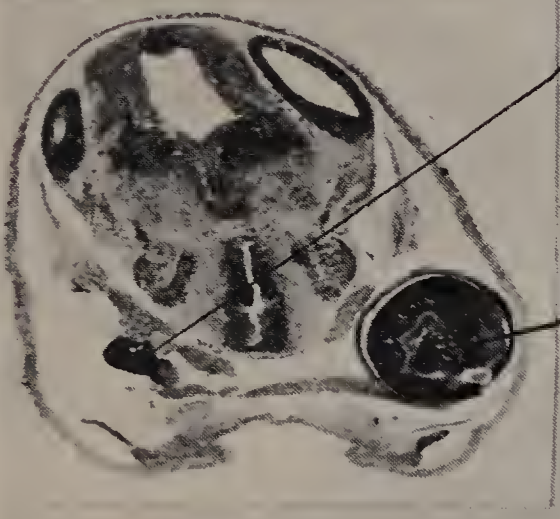

Fig. XIX

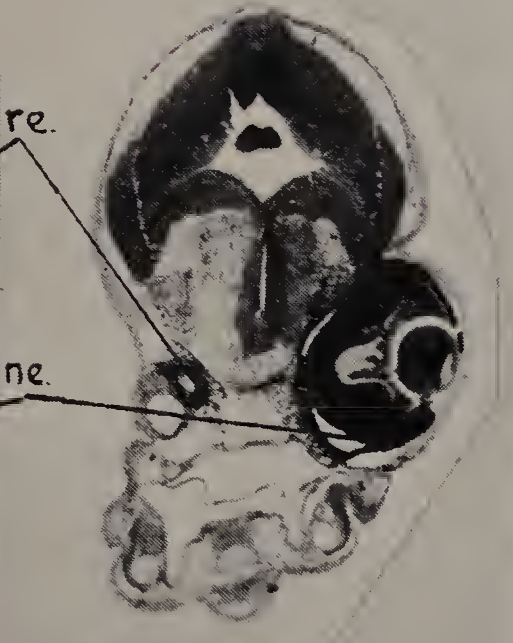

Fig. XX

WATER TEMPERATURES IN GRAND LAKE, NOVA SCOTIA.

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Fisheries Exp. Sta. (Atlantic), Halifax, N. S.

(Received August 20, 1934).

ABSTRACT.

A report of certain temperature records for Grand Lake, N. S. One of these shows an unusually sharp temperature change between the upper and deeper layers during the summer months, the temperature changing by over 5°C. in one metre.

Some records of temperature of the surface and deeper layers of water in Grand Lake, Nova Scotia, were made in the years 1927-1930. While the series is not complete the improbability of further observations being made soon renders it desirable to record the main features of those obtained.

The outline of Grand Lake is shown in Figure I. Soundings were taken on lines run across the lake at the points "A", "B" and "C", the lines being roughly perpendicular to the long axis of the lake. The greatest depths observed were 41 metres at "A", 33 metres at "B" and 34 metres at "C". Some sporadic soundings were taken at other points where deeper water was reported to occur but only lesser depths were found. Creditable reports indicate greater depths than the writer found, but it seems reasonably certain that such deeper areas are restricted in extent and that most of the lake is less than 35 metres deep.

The temperature records taken at points "A" and "B" were obtained from an anchored rowboat by means of Negretti and Zambra reversing thermometers. The principal data obtained are shown in Tables 1 and 2.

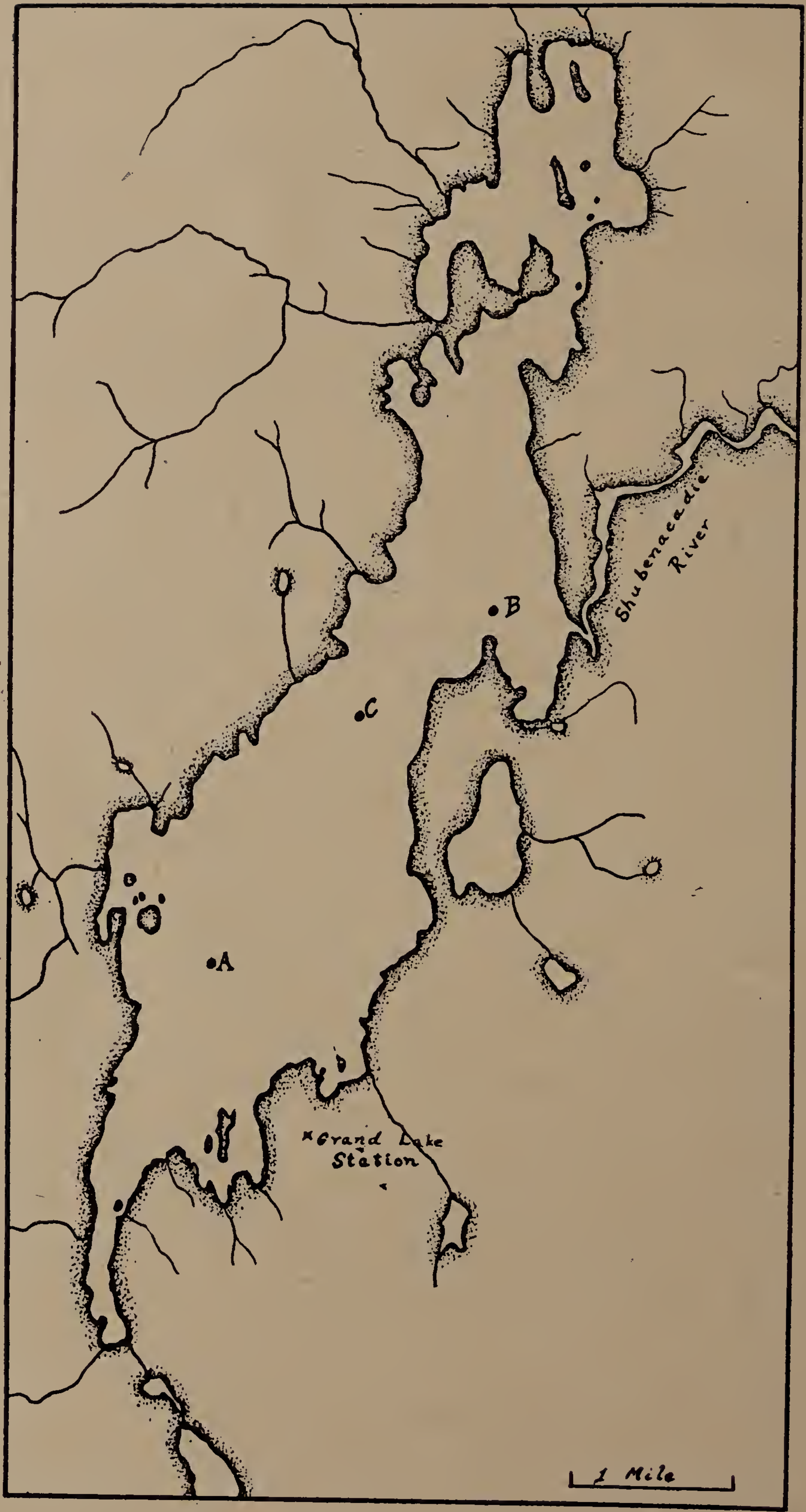

Fig. I.—Map of Grand Lake.

TABLE I.

Temperatures observed at Station "A" (°C.)

Depth (metres)	Aug. 20 1927	Oct. 1 1927	May 26 1929	June 23 1929	July 28 1929
0	21.5	16.0	8.8	17.3	20.7
10	18.9	15.9	8.2	10.9	16.0
15	12.7	15.4	....	9.0	9.9
25	10.2	....	8.0	8.4	8.9
35	10.0	10.2	8.0	8.4	8.8

TABLE II.

Temperatures observed at Station "B" (°C.)

Depth (metres)	Sept. 22 1929	Oct. 20 1929	June 8 1930	Aug. 3 1930	Sept. 1 1930	Sept. 28 1930	Oct. 12 1930	Nov. 10 1930
0	18.0	13.0	15.5	22.8	22.5	17.5	14.8	9.6
10	17.3	12.6	13.8	16.6	19.7	17.6	14.1	9.7
15	17.2	12.6	9.8	10.4	11.0	10.6	13.9	...
20	10.0	12.6	9.4	9.9	10.0	9.9	12.0	9.6
30	9.5	9.9	9.2	9.6	9.7	9.8	10.6	9.6

As would be expected from the depth of the lake in relation to its surface area the water becomes stratified in summer with the thermocline occurring at a depth of 10 to 15 metres. Above this level the surface waters become quite warm in summer, while the deep layers below the thermocline rarely reach a temperature of 10°C. Probably this deep water which remains cool all summer is a refuge for the salmon (local "grayling") which appear to remain in the lake during their entire life. By combining the records for stations "A" and "B" for 1929 the progress of the temperature changes in the spring, summer and fall months is apparent.

The thermocline was observed to be sharply delimited at certain times. This is shown by the following data taken on a very calm day when the depth of the readings could be accurately determined.

	Depth	*Temperature*
Sept. 28. 1930....................	12.5 metres	17.6°C.
	14 “	17.6
	15 “	10.6
	16 ‘	10.6
	20 “	9.9

It will be noted that at this time the temperature changed 7°C. in one metre.

The writer is indebted to Mr. R. Frank Eagar of Halifax for assistance in the provision of a map of Grand Lake from Geological Survey sources as well as for information on the depths of water, and to the Biological Board of Canada for the use of a reversing thermometer.

DETERMINATION OF THE INITIAL AND FINAL SETS OF PLASTER OF PARIS.

STEPHEN G. RITCHIE.

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(Received October 10, 1934).

ABSTRACT.

This communication is part of an investigation of dental plasters begun in 1929 with the assistance of Doctor A. W. Faulkner.. It deals with the setting points of plaster. The method of determination adopted in place of those usually in vogue uses the variation in conductivity measurements at the initial and final sets. These are the low and high points distinctly marked on the conductivity curves. The paper gives a description of the apparatus used and a tentative explanation for the form of the curves derived during the investigation.

During the course of an experimental investigation of the physical properties of plaster of paris for dental purposes, considerable difficulty was encountered when an accurate determination of the "set" was attempted. Since, with suitable treatment, plaster may be made to set almost at will, it soon became evident that a better method than those advocated would have to be found.

The official method presented by the A. S. T. M. for plaster is the same as that used in testing cements, viz.—the use of the Vicat needle. This was totally inadequate for accurate work and was therefore discarded.

Another method[1] used in some of the Canadian plaster mills as an easy and simple test was then tried. It is as follows:—"A piece of common window glass about eight inches square and 3/32 inch thick is used. One hundred grammes of the sample are mixed with enough water to make a paste of testing consistency previously determined. The paste is spread on the glass plate and flattened into a pat about 7/16 inch thick. The set of the plaster is considered complete when it separates from the glass of its own accord when the latter is flexed by pressure of the hands on the opposite edges of the plate. Upward pressure is applied by the index finger of one hand and downward pressure by the base of the thumb. The thumb of the other hand exerts downward pressure while the heel of the same hand presses upward. The plate is inverted while it is being flexed, and the time of setting is taken as the lapsed time for adding the water to the sample to when he pat leaves the plate."

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[1] Cole. *The Gypsum Industry of Canada.* Page 79.

For testing building plasters such methods as the above are perfectly satisfactory but in making up dental impression plasters with initial sets of one to one and a half minutes, and final sets of three, four or five minutes a better technique is necessary.

A conductivity method was found to answer the requirements. Two new dry cells, a microameter reading from 0 to 500, a cell to hold the plaster, and a switch were hooked up in series. The plaster container was constructed of two strips of hard rubber two and a half centimeters wide and eight centimeters long which formed the sides of the cell. The ends of the cell were squares of thin copper plate two and a half centimeters on the side and located five centimeters apart between the rubber strips, which were then clamped together and placed on a sheet of glass which formed the bottom of the container. Wires were soldered to the copper plates for attachment in the circuit. When the cell was filled with the plaster sample the microameter readings came well up on the scale.

Time was reckoned from the beginning of the mix to the final set, the initial set being also registered. The data derived from some sixty tests of raw and prepared plasters were extremely interesting. Two curves of prepared quick setting plasters are seen in Fig. I. In these curves it will be noted there is a rapid fall of the current to the point which marks the initial set of the plaster. After an interval, which varies in length according to the type of plaster used, the current begins to rise until it nearly, but not quite, reaches its original value. When the current has reached this highest point the final set may be considered complete for all practical purposes although hydration is still actively under way. The plaster is no longer soft or friable but breaks with a clean, sharp fracture. The expansion of the plaster is just beginning. After another interval the current again drops, much more slowly than before, and finally disappears completely as the insulator stage is reached. The time, as before, depends on the type of plaster under test.

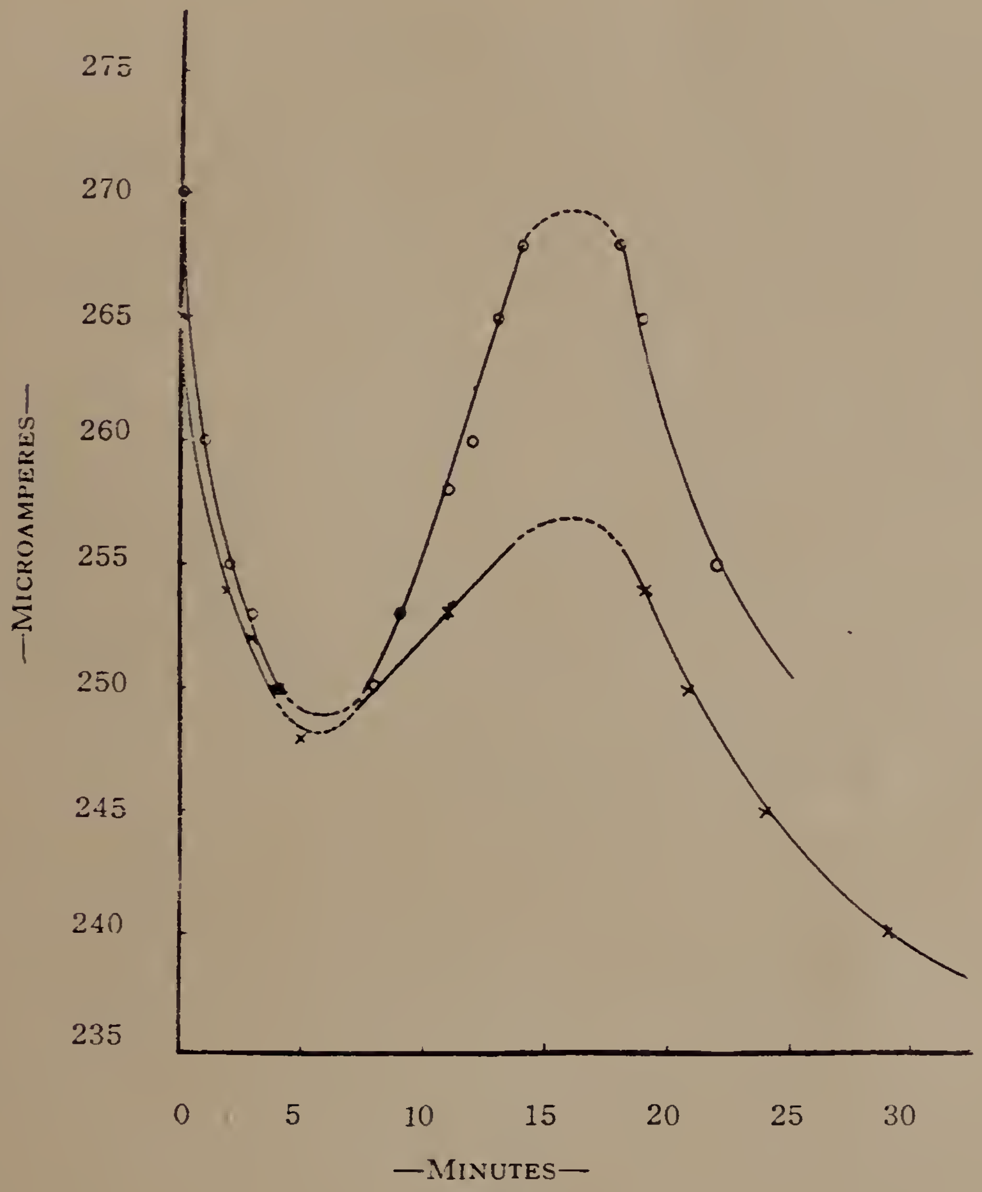

Fig. I.

It is difficult to explain the form of these curves, which, it may be said, is typical. A review of the literature indicates that the phase transformations of calcium sulphate and the properties of its dehydration products have remained a subject of controversy even to the present time. Possibly a plausible explanation may be found in the work of Davis[2].

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[2] Davis, W. A. *Jour. Soc Chem. Ind.*, 26, 727 (1907).

Davis has shown that when monoclinic gypsum is heated it first changes into a rhombic form before dehydration takes place. After dehydration the product is, of course, in the main the hemihydrate which is also rhombic in form. This reaction is strictly reversible. At this point it should be stated that van't Hoff and others have presented experimental evidence that before the expansion takes place in setting plaster a pronounced contraction occurs. Davis notes this fact and interprets it by showing that the preliminary contraction corresponds with the formation of the rhombic modification of gypsum, and the subsequent expansion with the conversion of the rhombic into monoclinic gypsum.

As a result of several comparative tests against the expansion apparatus it was found that the initial drop in the conductivity curve corresponds closely with the initial contraction in the expansion curve, or, as Davis puts it, to the change from the rhombic hemihydrate to the rhombic modification of gypsum. Why this change should be accompanied with such a sudden increase in the resistance of the plaster is a subject for further investigation.

THE SOLUBILITY OF GOLD IN FERRIC SULPHATE AND ITS GEOLOGICAL APPLICATIONS.

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(Received Nov. 8, 1934).

ABSTRACT.

Gold was found to be slightly soluble in ferric sulphate solutions, and quite soluble in solutions of ferric sulphate with a small amount of sulphuric acid. It is possible to explain the phenomenon of supergene enrichment of gold deposits by means of this solubility of the gold in ferric sulphate, which is formed by the oxidation of pyrites, a common associate of gold.

The question of the solubility of gold in ferric sulphate is of interest in Geology because it offers an explanation for one of the problems of Geology, viz., that of secondary enrichment of gold deposits. In some gold deposits there is evidence to show that some of the gold was deposited as the result of secondary action. It appears that the gold was concentrated in a lower horizon by supergene solutions which carried gold obtained by the leaching of an upper portion of the same deposit. What is the solvent responsible for this action?

Ferric sulphate has several times been suggested as this solvent, because it is formed in most gold deposits by the oxidation of pyrites, a common associate of gold. In the older literature ferric salts were mentioned as solvents of gold, but later writers have denied this, stating that gold can only be dissolved by solutions capable of producing nascent chlorine. H. Wurtz[1] has stated that gold is soluble in ferric sulphate under proper conditions, while Stokes[2], W. H. Emmons [3], J. R. Don[4], and others have said that ferric sulphate is ineffective in dissolving gold. This work was undertaken for the purpose of determining the solubility of gold in ferric sulphate.

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[1] H. Wurtz, *A. J. Sc.*, 1858, p. 51.
Lindgren, "*Mineral Deposits*", 3rd. ed., p. 966.

[2] Stokes, *Econ. Geology*, **1906**.

[3] W. H. Emmons, *Bull.* 625, *U. S. Geol. Survey.*

[4] J. R. Don, *Trans. American Inst. of Mining and Engineering.*

The solvent effect of ferric sulphate was tried in two ways, first by etching a polished surface of gold with the ferric sulphate, and secondly by placing gold in a solution of ferric sulphate and testing the solution for the presence of gold.

In the first method the solvent effect was shown by the way the polished surface was etched. In the second method the presence of gold in the solution was determined by means of a microchemical test, that described by Putnam, Roberts, and Selchow[5]. The reagent used was a 10% solution of pyridine in 40% hydrobromic acid. This solution, when added to a drop of the solution containing gold, gave a precipitate of fine feathery-like crystals, which, between the crossed nicols of the microscope, were bright yellow. The presence of the ferric sulphate gave a precipitate of larger red-colored crystals which could easily be distinguished from the crystals due to the gold. Blank tests were run on all the reagents so as to be sure that a positive result indicated without doubt the presence of gold in the solution.

First a rock specimen containing gold was polished and then placed in a solution of ferric sulphate. Due to the presence of carbonates in the rock it was necessary to add a small amount of sulphuric acid in order to keep the ferric sulphate in solution. In a solution at room temperature no sign of etching was visible at the end of fifteen minutes, but when the solution was warmed to about 70-80°C. the surface of the gold was seen to be slightly etched, showing the solubility of gold in the solution used. Due to the presence of the sulphuric acid in the solution it could not be determined whether or not gold is soluble in pure ferric sulphate, but only that it is soluble in ferric sulphate solutions containing a small amount of sulphuric acid. However natural supergene solutions contain sulphuric acid.

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[5] Putnam, Roberts, and Selchow, "*Contributions to Determinative Mineralogy.*"

In the second method gold foil was used. Small pieces were placed in various solutions and these solutions tested for gold.

The first solution of ferric sulphate after standing for half an hour did not give a definite test for gold, but on standing over night enough gold dissolved to give a satisfactory test showing the presence of gold.

Another solution was heated to about 70-80°C., and after fifteen minutes the test showed the presence of gold in the solution.

The next solution was boiled in order to hasten the action. After twenty minutes the presence of gold in the solution was shown by the microchemical test. This, however, has no application to the problem of supergene enrichments, since these solutions do not reach such a temperature.

Another solution was made up containing besides the ferric sulphate about one per cent. of sulphuric acid. This boiling solution completely dissolved quite a large piece of the gold foil, and upon cooling some of the gold was deposited as a film on the surface of the liquid.

These experiments show that gold is slightly soluble in cold solutions of ferric sulphate, and at higher temperatures the solvent action is greater. The presence of a small amount of sulphuric acid greatly increases the solubility of the gold.

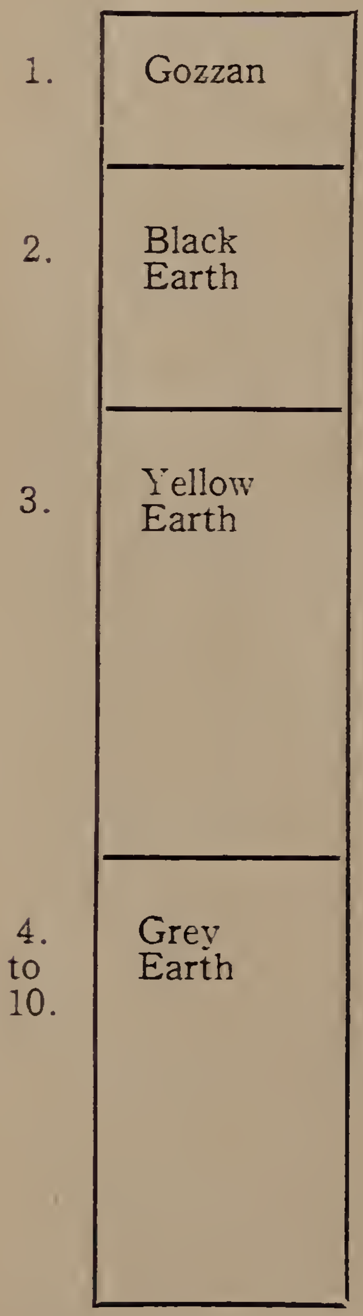
A test for ferrous sulphate was negative, so it appears that the gold does not reduce the ferric sulphate.

In supergene enrichments of gold deposits it is supposed that the ferric sulphate and sulphuric acid is formed by the oxidation of iron pyrites as follows:

$$\begin{array}{l} FeS_2+H_2O+7\ O \longrightarrow FeSO_4+H_2SO_4 \\ 2\ FeSO_4\ H_2SO_4+O \longrightarrow Fe_2(SO_4)_3+H_2O \\ \hline 2\ FeS_2+H_2O+15\ O \longrightarrow Fe_2\ (SO_4)_3+H_2SO_4 \end{array}$$

An example of this secondary enrichment is found in the gold deposits at the Rio Tinto Mine in Spain. The ore is pyrites carrying copper and a little gold. The deposit has been oxidized at the surface leaving a gozzan. Below this gozzan is a thin layer of black to yellow muddy material, about twenty to thirty centimeters thick. This layer has a much higher gold content than the rock above or below. This is the result of secondary enrichment. The oxidation of the pyrites above formed ferric sulphate and sulphuric acid, which seeping downwards dissolved the gold in the ore, and when it reached the fresh pyrites the gold was precipitated. The analysis of these different layers is shown in the accompanying diagram.

PROPORTIONS OF GOLD AND SILVER AT VARIOUS DEPTHS AT RIO TINTO.



	Gold	Silver
1.	5.2	2.68
2.	33.6	83.43
3.	23.2	50.69
4.	6.4	25.48
5.	7.2	
6.	6.0	
7.	3.2	
8.	4.0	
9.	2.6	
10.	3.6	

Gold in grams per 1,000 kilograms.
Silver in oz. per ton.

Figures through courtesy of Prof. G. V. Douglas.

This theory accounts for the gold in these layers. If ferric sulphate acting for only a short time in the laboratory can dissolve gold, then in the long time in which it could act in nature it could leach out the gold in the oxidized portion of an ore body and account for the lower enrichments.

The case of the Rio Tinto deposits has been described by Prof. G. V. Douglas[6] and Prof. Davis Williams[7], and similar cases have been reported by other writers from South Africa and South America. Ferric sulphate, with sulphuric acid, seems to be the general solvent in these cases, and due to its common occurrence it is probably the chief solvent responsible for supergene enrichments of gold deposits.

This work was done as part of a course in Geology at Dalhousie University under the direction of Professor G. V. Douglas. It is a pleasure to acknowledge the assistance of Prof. Douglas and also of Mr. C. W. McKinnon, who helped not only in the work but also in preparing the paper for publication.

[6] G. V. Douglas, *Geol. Mag.*, Vol. **66**, p. 302.

[7] D. Williams, *Inst. of Mining and Metallurgy*, April, 1934.

FRACTIONAL DISTILLATION: ANALYSIS OF ORGANIC LIQUIDS.

Harold S. King.
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(Received Nov. 20, 1934).

ABSTRACT.

Apparatus is described for the accurate fractional distillation of organic liquids. The course of the distillation is followed by determining the weight and refractive index of each fraction. From these values the percentage of each constituent in the mixture is calculated.

The analysis of organic liquids by means of careful fractional distillation has proven so useful and accurate that a more extended description of the apparatus and method, than has previously been given[1], seems advisable.

Figure I gives a diagrammatic representation of the distillation apparatus. The 1-liter distilling flask *A* rests in a metal bath which is heated electrically. The temperature is controlled by a variable resistance. A weighed amount of the liquid to be analyzed is put into the flask and one glass bead *B* is added to prevent bumping. During the distillation the bead dances up and down, giving off a stream of bubbles each time it touches the bottom of the flask. The vapour passes into the fractionating column of 8 mm. internal diameter. The jacketed part of this column is 110 cm. long. A distinctive feature is that an even spiral, 4 turns in 15 cm., is pressed into this column. This spiral brings about a more efficient interchange between the descending liquid and the ascending vapour without holding up too much liquid. The rather fragile column is strengthened by being enclosed in a slightly larger tube. The space between is filled with magnesia packing which equalizes the heat generated by a coil wound on the whole length of the tube. The amount of heating is controlled by a variable resistance. About the column is an asbestos heat insulator. Above the heating unit the fractionating column passes into a cooling device *D*, 12 cm. long. The cooling is regulated by a constant level syphon device (not shown in cut) which may be raised or lowered. Above the cooler the column is bent in a semi-circle and is wrapped with asbestos to avoid irregularities due to drafts. At the top of the bend a glass diaphragm *E* prevents the sweeping over of liquid along the sides of the glass tube. No thermometer is used, since this holds back sufficient liquid to decrease the accuracy of the analysis. The downward portion of the column is cooled by a condenser *F*, 15 cm. long, and passed into a receiver *G*, from which the condensate may be withdrawn at intervals into small weighed containers *H* without destroying the vacuum. The apparatus is evacuated to the desired pressure through *J*, which leads to a manometer and an oil pump. Before reaching the pump the vacuum line includes a tube about 100 cm. long and 5 cm. wide packed with broken sticks of potassium hydroxide in order to protect the pump from any acid fumes. To minimize the effect of any small leakages in the apparatus several empty Winchester bottles are included in the line. The containers *H* are made by cutting down 1.8 cm. test tubes to 6 cm. length. 50 cc. pyrex flasks may be substituted when it is desired to collect larger fractions.

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[1] King and Beazley, *Proc. N. S. Inst. Sci.*, **18**, 204 (1934).

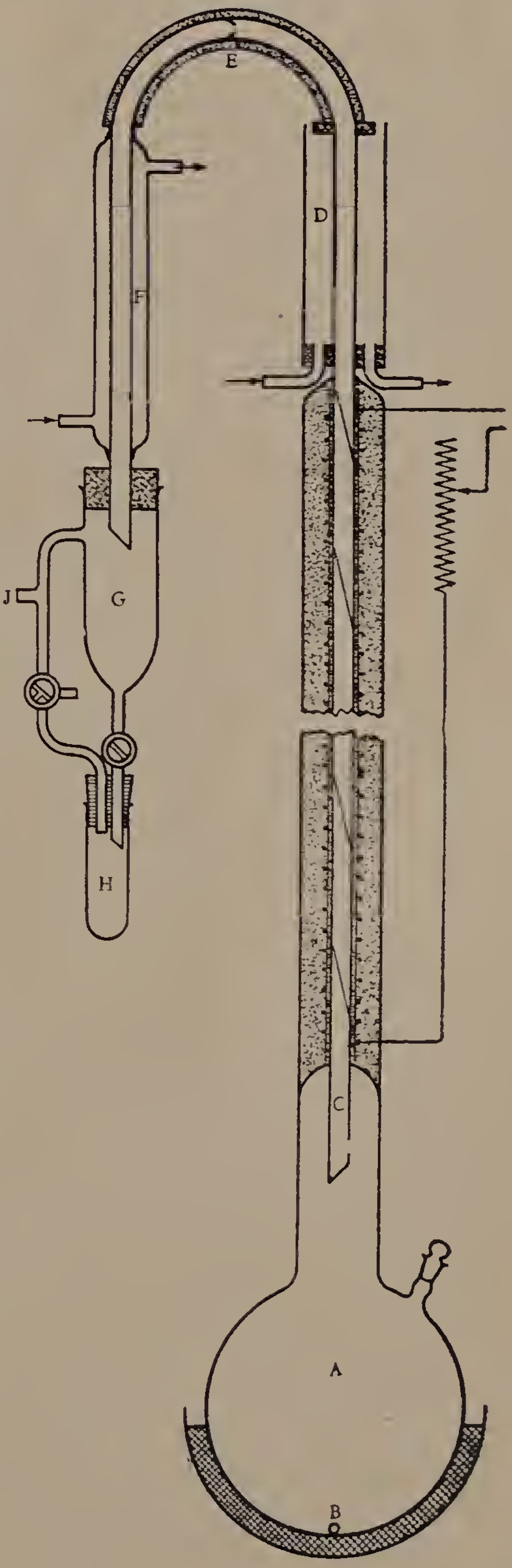

Fig. I.

Three hundred grams of the sample are heated in the distilling flask under reduced pressure until the reflux from the fractioning column drips at just a countable rate. The fractionating column is heated until refluxing takes place in the water-filled cooler. The level of the water is lowered until the ratio of the drops in the reflux to those delivered into the receiver is about 10 to 1. In early experiments with this apparatus the vacuum was held constant automatically, but it was noticed that, whenever the pump started, a flood of vapour passed over, so in later experiments the pressure was brought to the desired point before collecting a sample. During the collection of the sample the pressure remains practically constant. If there is any material change in pressure it is adjusted between the taking of samples, the cooler being filled with water to prevent distillation during the operation.

Each sample is received into a weighed container, weighed, and its refractive index determined by an Abbé refractometer.

This method of analysis does not require complete separation of the constituents. For accuracy it does require that certain samples only be pure, and that the intermediate fractions be mixtures of only two constituents. Let us assume that in a distillation a series of samples have constant refractive indices. Then these samples are composed of a single component *A* (either a pure substance or a constant boiling mixture). If succeeding samples have rising refractive indices followed by another series with constant refractive indices of component *B*, it is assumed that the intermediate samples are composed of mixtures of *A* and *B*. By making up known samples of various mixtures of *A* and *B* and determining their refractive indices, a curve relating refractive index and percentage composition is obtained, and the composition of any unknown mixture may be easily determined. If a linear relation holds, then the weight of one constituent *X* may be calculated from the formula.

$$x = \frac{ab}{c}$$

where a = wt. of the fraction.
b = $^{n}_{D}$ of sample − $^{n}_{D}$ of A.
c = $^{n}_{D}$ of B − $^{n}_{D}$ of A.

The summation of the analyses of each fraction gives the composition of the original sample.

Two errors are introduced in this method of analysis. It is impossible to distil all the liquid, so a small part is left as residue. Also a few grams are lost by volatilization during the distillation.

Examples of analyses made by this method are given in a previous paper[1] and in that following[2].

We wish to acknowledge the assistance of Mr. W. B. Beazley in setting up the distillation apparatus.

[2] King and Merriam, *Proc. N. S. Inst. Sci.*, 18, 276, (1935).

PREPARATION OF m-XYLYL CHLORIDE.

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(Received November 20, 1934).

ABSTRACT.

Meta-xylene was chlorinated in a special apparatus to yield m-xylyl chloride without the production of dichloro-derivatives. The product was fractionally distilled and the composition of each fraction determined by its refractive index. The total yield of m-xylyl chloride, based on chlorine used, was 76%. The ratio between nuclear and side-chain chlorination was approximately 1:10. The presence of oxygen in the chlorine slowed down the chlorination tremendously and the product could not be distilled because of decomposition with evolution of hydrogen chloride. The following refractive indices were determined with an Abbé refractometer: m-xylene, $n_D^{25} = 1.4955$; 4-chloro-1.3-dimethyl benzene, $n_D^{25} = 1.5230$; m-xylyl chloride, $n_D^{25} = 1.5327$.

The side-chain chlorination of m-xylene presents a more difficult problem than arose in the case of toluene[1]. If chlorine be bubbled into boiling m-xylene, not only m-xylyl chloride is formed, but also 4-chloro-1.3-dimethyl benzene and dichloro-derivatives of m-xylene. Since the boiling point of m-xylyl chloride lies intermediate between that of the nuclear chlorinated product and that of the dichloro-derivatives, its isolation from such a mixture is difficult. Attempts were consequently made to prevent or materially reduce the production of all chlorinated products except m-xylyl chloride. We were successful in preventing the formation of dichloro-derivatives and, by so doing, simplified the fractional distillation and obtained good yields of product.

The xylene used in these experiments was purified by the method of Spannagel and Tschunker[2]. Technical m-xylene, B. Pt. 137-139°, was cooled in a bath of dry ice and alcohol to below -55°. There was a copious crystallization of p-xylene. The unfrozen m-xylene was sucked out by inverted filtration.

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[1] King and Beazley, *Proc. N. S. Inst. Sci.* **18**, 204-212 (1934).

[2] Spannagel and Tschunker, *Ger. Pat.* 567,331, Dec. 16, 1927; *C. A.* **27**, 1366 (1933)

In the chlorinations we wished to know the exact amount of chlorine used. The large tanks of liquid chlorine could not be weighed with sufficient accuracy, so chlorine was transferred to a small cylinder weighing approximately 500 gms. The small cylinder, connected to the large one by a piece of sulphur-free rubber tubing well wired on, was cooled with dry ice in alcohol. The large tank was turned on and the pressure regulated by noting the swelling of the rubber tubing. In a very short time a sufficient weight of chlorine had been liquified in the small cylinder. To free the chlorine from any admixed oxygen, the valve to the small cylinder was opened before the cylinder had warmed up and a small amount of chlorine was allowed to escape.

After several trials the chlorinating apparatus illustrated in Fig. I was constructed. With this chlorinator the dichlorination of xylene was almost entirely prevented for a large excess of xylene vapor was rapidly mixed with a slow stream of chlorine and the products were immediately removed to prevent further admixture with chlorine. The apparatus was of Pyrex glass throughout. A 500 cc. distilling flask (A) was used, though a larger one could be substituted without changing the dimensions of the rest of the apparatus. The neck of this flask ($\frac{3}{4}$ inch in diameter and 5 inches long) was sealed into one end of the chlorinating chamber (B) which was 20 inches long and 2 inches in diameter. The chlorine inlet (C) was of $\frac{1}{2}$ mm. capillary tubing set directly opposite to the centre of the neck of the distilling flask. The apparatus was sealed to an

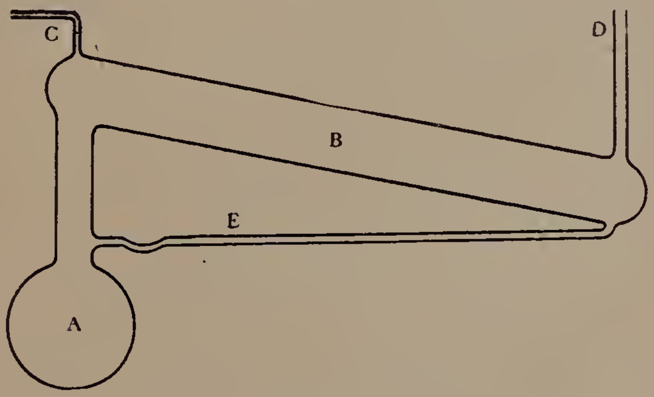

Fig. I.

efficient reflux condenser at (D) which in turn was connected to the hydrogen chloride absorbers. The reflux was returned to the distilling flask through (E). The chlorinating chamber was illuminated by a 500 watt, nitrogen-filled bulb. In a preliminary experiment, the chlorine inlet was of $\frac{1}{4}$ inch tubing sealed in line with the chlorinating chamber instead of at the top. This was found unsatisfactory. A small amount of dichlorinated derivatives was produced. Unless the flow of chlorine was cut very low, part of it passed unreacted to the absorbers. There was a tendency for condensed liquid to back up the wide tube against the flow of chlorine.

The following description of a typical chlorination illustrates the method. 260 gms. of m-xylene were put into the distilling flask and boiled until all water had been swept out of the apparatus through the uncooled condenser into the absorbers. Then the condenser was cooled and the rate of boiling was regulated so that refluxing took place only in the lower end of the condenser. The light was turned on and 126 gms. of chlorine (determined by loss of weight of cylinder), dried by sulphuric acid, were passed in at the rate of about 40 gms. per hour. After the chlorination was complete, 17 gms. of xylene were found in the absorbers, so that 243 gms. of xylene were used in the chlorination. The product weighed 305 gms.

300 gms. of the product were analyzed by fractional distillation using the method previously described[3]. Table 1 and Fig. II give the results. The residue in this distillation, 18.7 gms., was much larger than in the case of the similar analysis of crude benzyl chloride[1]. It seemed to be tarry in character rather than composed of dichloro-xylene derivatives.

Since there was no distinct break in the distillation curve corresponding to 4-chloro-1.3-dimethyl benzene, some of this substance was prepared in a separate experiment by bubbling chlorine into m-xylene in the presence of iodine as a catalyst. The nuclear chlorinated product was fractionated and the pure fractions had a constant refractive index of $n_D^{25} = 1.5230$.

King, *Proc. N. S. Inst. Sci.* 18, 272 (1935).

The refractive indices of m-xylene and m-xylyl chloride, determined with an Abbé refractometer, had the following values: m-xylene, n_D^{25} = 1.4955; m-xylyl chloride, n_D^{25} = 1.5327. The refractive indices of mixtures of (a) m-xylene and chloro-m-xylene and (b) chloro-m-xylene and m-xylyl chloride were assumed to be related to the percentage composition linearly.

The weight of one constituent (x) in a sample was calculated from the following formula:

$$x = \frac{ab}{c} \qquad \text{where}$$

a = wt. of fraction and
in the case of m-xylene and chloro-m-xylene mixtures
b = n_D of sample—n_D of m-xylene
c = n_D of chloro-m-xylene—n_D of m-xylene = 0.0275
and in the case of chloro-m-xylene and m-xylyl chloride mixtures,
b = n_D of sample—n_D of chloro-m-xylene
c = n_D of m-xylyl chloride—n_D of chloro-m-xylene = 0.0097

From these calculations the composition of each fraction was determined, and the summation gave the composition of the original sample.

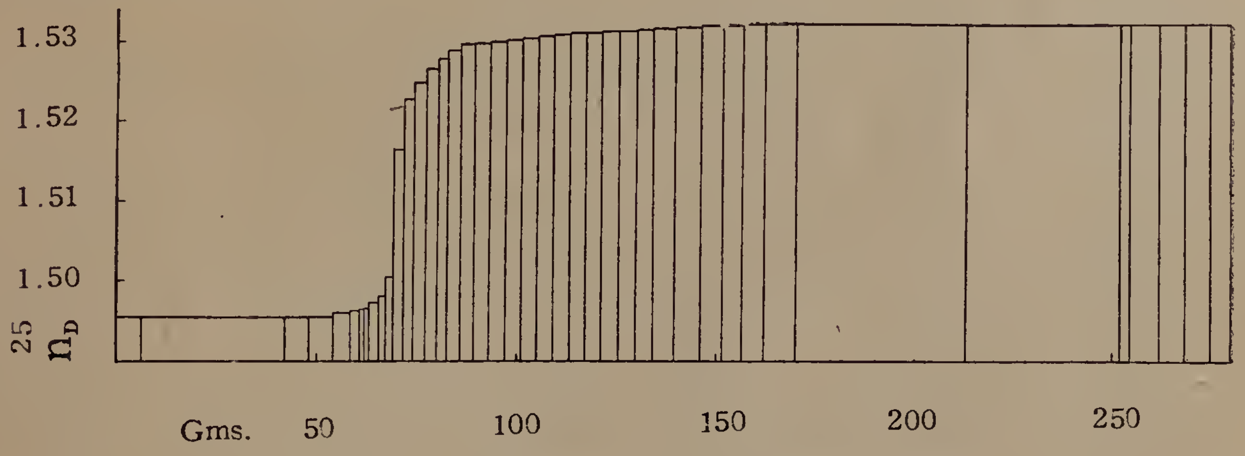

Fig. II. Fractional Distillation Graph.

In round numbers this analysis indicates that the product of chlorination of m-xylene in the presence of light contains by weight 23% m-xylene, 7% 4-chloro-1.3 dimethyl benzene and 64% m-xylyl chloride. The ratio, therefore, between nuclear and side-chain chlorination is approximately 1:10. The percentage yield of total m-xylyl chloride (190.8 gms.)

TABLE 1.

Analysis of Chlorinated m-Xylene.

Fraction	Wt. gms.	n_D^{25}	Wt. m-xylene	Wt. chloro-xylene	Wt. m-xylyl chloride
1	6.41	1.4950	6.41	....	....
2	36.10	1.4955	36.10	....	....
3	5.41	1.4955	5.41	....	....
4	5.91	1.4956	5.89	0.02	....
5	4.62	1.4961	4.52	0.10	....
6	2.22	1.4964	2.15	0.07	....
7	1.21	1.4966	1.16	0.05	....
8	1.38	1.4967	1.32	0.06	....
9	2.17	1.4974	2.02	0.15	....
10	1.90	1.4981	1.72	0.18	....
11	1.84	1.5005	1.51	0.33	....
12	2.54	1.5167	0.58	1.96	....
13	2.33	1.5230	....	2.33	....
14	2.92	1.5252	....	2.26	0.66
15	2.96	1.5270	....	1.74	1.22
16	2.67	1.5282	....	1.24	1.43
17	3.26	1.5293	....	1.14	2.12
18	3.21	1.5300	....	0.89	2.32
19	4.17	1.5302	....	1.07	3.10
20	4.02	1.5304	....	0.95	3.07
21	3.98	1.5306	....	0.86	3.12
22	3.57	1.5308	....	0.70	2.87
23	4.11	1.5312	....	0.64	3.47
24	4.12	1.5313	....	0.59	3.53
25	4.22	1.5315	....	0.52	3.70
26	3.90	1.5316	....	0.44	3.46
27	4.34	1.5318	....	0.40	3.94
28	4.07	1.5318	....	0.38	3.69
29	4.54	1.5319	....	0.37	4.17
30	5.52	1.5321	....	0.34	5.18
31	6.31	1.5323	....	0.26	6.05
32	5.55	1.5325	....	0.11	5.44
33	5.12	1.5326	....	0.05	5.07
34	5.45	1.5327	....	....	5.45
35	7.77	1.5327	....	....	7.77
36	43.27	1.5327	....	....	43.27
37	38.91	1.5327	....	....	38.91
38	2.50	1.5327	....	....	2.50
39	7.61	1.5327	....	....	7.61
40	6.63	1.5327	....	....	6.63
41	6.45	1.5327	....	....	6.45
42	4.63	1.5327	....	....	4.63
..	....	......	68.79	20.20	190.83

based on the chlorine from the cylinder, is 76%. If the yield be taken to be the fractions 30-42 inclusive, then the percentage yield is 59%. This can be considerably increased by re-fractionating the intermediate fractions.

In certain experiments using earlier forms of the chlorination apparatus, the refractive indices of the last fractions were greater than that of m-xylyl chloride, indicating the presence of dichlorinated products. With the final form of the chlorination apparatus there was no indication of the formation of dichloro-xylene derivatives. The distillation merely slowed down at the end and, when the heat under the still was increased and the pressure was reduced, the product became colored. This indicates that dichloro-derivatives are formed from the mono-chloro-derivatives and not directly from m-xylene.

Several attempts were made without success to decrease the amount of nuclear chlorination. It was hoped that the presence of oxygen would slow down nuclear chlorination more than side-chain chlorination[4]. Duplications of the above described chlorination were made with the exception that oxygen and chlorine were both added in about equal volumes. The chlorination was very slow. Though it took 26 hours to add 132 gms. of chlorine, much went through unreacted to the absorbers. The product was very dark in color. On heating the product, hydrogen chloride was evolved at such a rate that fractionation was impossible. Possibly a Friedel and Crafts reaction took place, the oxidized products acting catalytically. Or it is possible that a large amount of an addition product between m-xylene and chlorine was present and, on heating, decomposed with the elimination of hydrogen chloride.

We wish to acknowledge our indebtedness to Mr. C. C. Forward, Dominion Government Analyst, who loaned us the Abbé refractometer used in this investigation.

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[4] Hannon and Kenner, J. *Chem. Soc.* **1934**, 138.

THE EFFECT OF SOME BARBITURIC ACID DERIVATIVES ON THE INTESTINE OF THE CAT*.

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(Received March 4, 1935).

ABSTRACT.

All members of this series stimulate gastric and intestinal movements, when administered intravenously. The action is peripheral for it is not abolished by Section of vagi or splanchnic nerves, or after the injection of atropine.

The action of diethyl barbituric acid (Veronal), or its sodium salt, and other members of this group, on the blood pressure has been investigated frequently. There is a fall in blood pressure caused partly by a depression of the vasomotor centre and partly by a direct depressent action on the blood vessels. Sodium amytal and luminal act in a similar fashion. The depressent action on smooth muscle appears to be a direct one. Recently Gruber[1] and his co-workers have described the depressent effect of sodium phenobarbital on the intestine of the unanaesthetized dog. The doses employed, intravenously, varied from 33 to 42 milligrammes per kilogramme. The rate of injection and concentration of the solutions are not stated, and this may account for the difference in the results obtained in the present investigation on the cat's intestine.

The method employed has been described elsewhere[2]. All injections were made intravenously and dosage refers to milligramme per kilogramme. All the barbiturates were converted into the sodium salts and these were dissolved in 0.9% sodium chloride solution. Each injection took from five to ten seconds. The concentration of the solutions was usually

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[1] Gruber, Crawford, Greene and Drayer: *Journ. Pharm. and Exp. Therap.*, Vol. XLII, 1931.

[2] Babkin: *Die Aussere Sekretion der Verdauungsdrusen.* 2nd Edition, 845, 1928.

*Preliminary Report.

1%, as higher concentrations required slower rates of injection and, further, they have been known to cause serious depression of the circulation.

Results.—The first salt tested was sodium phenobarbital. In the first series of observations the dosage never exceeded ten milligrammes. The result was always a pure stimulation. Quantities varying from 2.5 milligrammes to ten milligrammes produced similar effects (Fig. I). This was in marked contrast to the results of Gruber, who obtained a pure depression. The quantities injected into their dogs varied, as stated above, from 33 to 42 milligrammes per kilogramme. Since the cats were already anaesthetized it was not possible to inject large

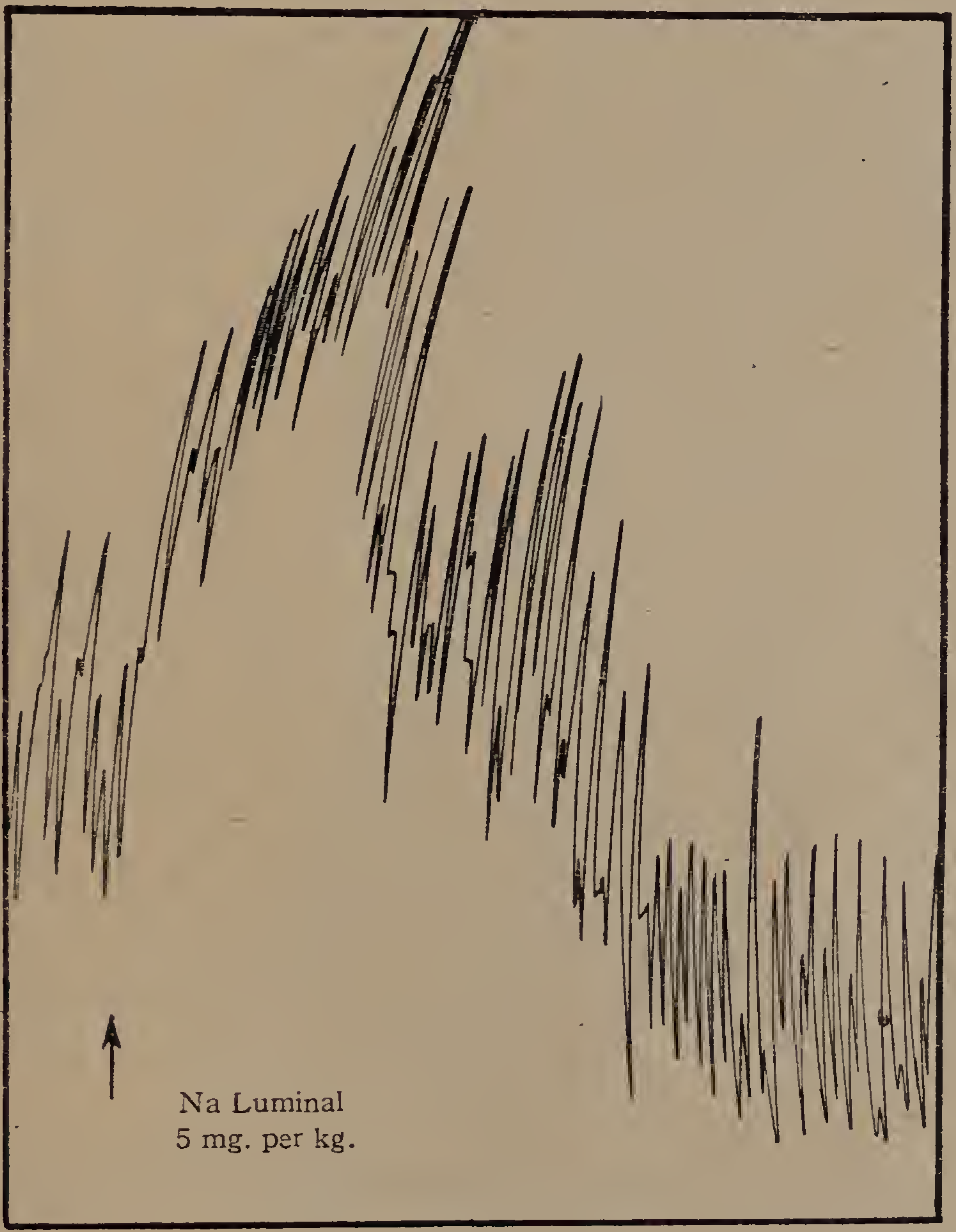

Fig. I.

quantities of a hypnotic for fear of depressing respiration and circulation too much. To overcome this the following procedure was adopted. Cats were anaesthetized with ether, the abdomen opened and a loop of intestine prepared. Following this the cat was decerebrated and allowed to recover from the shock of the operation. An initial injection of 2.5 milligrammes gave a stimulation as in the anaesthetized cat. Instead of the small doses previously given, the second quantity injected was increased to twenty-five milligrammes. The result was still a stimulation, the tonus being increased very considerably and the movements were but slightly changed. The intestine returned to its initial state after a period of about twenty minutes. A second injection of 25 milligrammes of sodium phenobarbital gave an effect like the first, but in this instance the movements were larger. The cat's circulation and respiration were not depressed by this amount of drug. Morphine, 1 milligramme, was next injected, but the stimulation from this was slight. A third injection of 25 milligrammes of phenobarbital caused an increase in tone of the intestine. Finally the quantity of phenobarbital was raised to 50 milligrammes per kilogramme, an amount exceeding that recorded by Gruber. Instead of an immediate depression of movements, there was a stimulation lasting for a few minutes, before an abrupt fall in tone and decrease in amplitude set in, but this coincided with the failure of respiration and circulation. The effect of high concentration of drug has not yet been tried, but it is possible that concentration may play a part in producing a depression of movements.

The extrinsic nerve supply did not interfere with this stimulant action of sodium phenobarbital, for identical results were obtained after section of the vagi and splanchnic nerves. Increased intestinal tonus following morphine injection or section of the splanchnic nerves did not alter the effect of the phenobarbital. The result of injection of this drug in all the conditions studied so far was a stimulation of intestinal movements.

Sodium amytal (isoamylethyl barbituric acid), which is largely used as a basal narcotic, was also investigated. The results resembled those of phenobarbital, and will not be described in detail. The doses employed were comparable to those of phenobarbital.

Other barbituric acid derivatives were tested and every one gave responses similar to amytal and phenobarbital. In some cases the action was not so prolonged, while in others the stimulation was more intense, but of short duration. In this group are included diethyl barbituric acid (veronal), diallyl barbituric acid (dial), cyclohexemyl ethyl barbituric acid (phanodorn), and pentobarbital.

The large intestine reacted like the small intestine in its responses to babiturate injections.

PRESIDENTIAL ADDRESS.

A. H. LEIM.

(Read October 11, 1933).

It is my privilege to-night to present a brief review of the events of the seventy-first session of the Nova Scotian Institute of Science, which session has just closed.

One of the duties devolving on the President at this time is happily light. No members of the Institute have died during the year.

During the session six ordinary meetings were held at which the average attendance was twenty. Three ordinary members and one student member were elected to the Institute.

From the surplus accumulated during the seventieth session amounts of five hundred dollars each were set aside in the Reserve Fund and the Permanent Endowment Fund. These amounts were invested in a Dominion of Canada long term bond.

The Provincial Government grant of five hundred dollars was again given during this year.

Part II of Volume 18 of the "Proceedings" was issued and the thanks of the Institute are due to the Editor and the Editorial Board for having carried out the work preparatory to its publication. It is gratifying to note an increase in size of the publication over that of the preceding year; a growth which will be continued in part III of the volume.

It has been encouraging to note that a paper originating outside the Maritime Provinces but dealing with the fauna of these provinces has been sent to us for publication by Dr. E. M. Walker. This paper will be doubly welcome as belonging to the category of natural history lists, the absence of which from the "Proceedings" of recent years has been repeatedly deplored.

The scientific papers presented at the ordinary meetings have been varied and interesting. Fifteen papers were included, four of them being joint ones. While all might not agree with my classification they may be referred to the following groups:

Three each in the fields of Chemistry and Zoology.
Two each in Biochemistry and Physics.
One each in Anatomy, Bacteriology, Geology, Meteorology and Navigation.

None of the papers presented was of a highly popular nature and in planning the programme for the coming year it would seem desirable to include at least one evening when a distinctly popular lecture would be presented after suitable advertisement. This would be in accordance with the desire formerly expressed by the Institute.

I should like to take the liberty of suggesting that the time is ripe for another in the series of Science Exhibitions. Two of these were carried through by the Institute in November of 1926 and 1928 and the record indicates that they were successful beyond the expectations of those concerned at that time. This seems to have been generally recognized among the members of the Institute and by many non-members who assisted in preparing and demonstrating the exhibits. The one objection which has been voiced concerns the great amount of effort which is necessary in staging such an exhibit.

One of our main reasons for believing that it is time for another such exhibit is that the student body at the University will have almost completely changed since 1928. If it can be arranged we would consider it to be a worth while endeavour to have one of these exhibitions sufficiently often so that each group of students would have an opportunity once during their college course of learning something of scientific methods and results. To those students who are enrolled in science courses such an exhibit is perhaps not very necessary or valuable but to students in Faculties other than Science and Medicine such an exhibition offers much.

Every four or five years is perhaps not too often to remind the less transitory residents of Halifax that the Institute exists and that research work is being carried on in this city and elsewhere in the province.

We would further suggest that the Institute consider limiting any individual Science Exhibition to one or two of the Departments of Science rather than attempting to include them all. By choosing the groups in rotation the necessary effort would be lessened and the exhibition could be confined to one building or at most to two adjacent ones.

Our Secretary in his capacity as Librarian of the Provincial Science Library has reported a decided growth in the use of that library during recent years. This is a matter of gratification to the Institute which has had such a large share in building up the Science Library.

In conclusion I wish to thank the members of the Institute for honouring me by my election as President. It is a pleasure to acknowledge the assistance of the members of the Council in administering the affairs of the Institute.

PROCEEDINGS OF MEETINGS.

SESSION OF 1933-34.

(*All meetings were held in the Medical Science Building, Halifax*).

72nd Annual Business Meeting, Oct. 11, 1933. The President, Dr. A. H. Leim, in the chair. Others present: Dr. G. H. Henderson, Dr. H. S. King, D. J. Matheson, Dr. E. Hess, Capt. W. F. Mitchell, Dr. S. G. Ritchie, Dr. J. H. L. Johnstone, Dr. E. G. Young and H. Piers.

The President delivered an address in which he reviewed the work of the Institute during the past year. So far as known no death had occurred in the roll of members.

The Treasurer's report showed that the receipts for the year were $2,141.16; expenditures, $1,320.38; balance in current account, $820.78; in reserve fund, $732.13; and in permanent endowment fund, $2,500.00.

The Corresponding Secretary reported that 183 back numbers of the Proceedings had been mailed. The mailing list of the Proceedings had been revised, and now contains the names of 98 members; 349 scientific societies, libraries, government departments and museums in 53 countries, with which an exchange of publications is maintained; and 323 university and college libraries, government departments, etc., to which complimentary copies are sent. This makes a total mailing list of 770.

The Librarian reported that, during the year ended Sept. 30, 1933, 3,463 books and pamphlets had been received through the Institute's exchange list; and that the total number in its library on that date was 69,707. The number of accessions to the entire Provincial Science Library (with which that of the society is incorporated) in the same period was 3,739; and the total number in the Library on Sept. 30, 1933 was 89,916. Of these, 69,707 belong to the Institute; 19,885 to the Science Library proper; and 324 to the Hugh Fletcher Memorial Library. With the Government's grant of $500.00 a number of books on pure and applied science were purchased, and 113 volumes were bound. During the year 881 books were borrowed besides those consulted in the Library.

The Editor reported on progress in printing the Proceedings.

The following were elected officers for the year 1933-34: *President*—Alexander H. Leim, Ph.D., ex-officio F.R.M.S.; *vice-presidents*—Prof. George H. Henderson, Ph.D., Prof. Harold S. King, Ph.D.; *treasurer*—D. J. Matheson, B.Sc.; *corresponding secretary*—Ernest Hess, Ph.D.; *recording secretary and librarian*—Harry Piers; *councillors without office*—D. J. Mackenzie, M.D., Capt. W. F. Mitchell, Rev. Bro. W. Cornelia, Prof. C. C. Coffin, Ph.D., Prof. F. R. Hayes, Ph.D., D. Mainland, M.D., and Prof. R. J. Bean; *auditors*—Prof. W. P. Copp and P. R. Colpitt.

1st Ordinary Meeting, Nov. 13, 1933.—Prof. F. R. Hayes presented a paper on "The Metabolism of Developing *Cyclopterus lumpus* Eggs;" and Prof. G. H. Henderson, one on "A New Method of Determining the Age of Minerals."

2nd Meeting, Dec. 11, 1933.—It was announced that Drs. J. S. Bagnall, D. LeB. Cooper and W. W. Johnston, of Halifax, had been elected ordinary members on Nov. 27. Papers were presented by Prof. Muriel V. Roscoe, Wolfville, on "The Cytology of Certain Cultivated Apples;" by Prof. N. B. Dreyer on "The Effect of Some Barbituric Acid Derivatives on the Intestine of the Cat;" and by E. Hess on "Cultural Characteristics of Marine Bacteria in Relation to Low Temperatures."

3rd Meeting, Jan. 15, 1934.—On motion of Mr. Piers and Dr. Ritchie it was resolved that the N. S. Institute of Science learns with deep regret of the death of its senior member, Dr. John Stewart, who passed away at Halifax, Dec. 26. He had joined the Institute Jan. 12, 1885, and for many years was a frequent and much interested attendant at its meetings. The Institute desires to express its sympathy with the members of his family in the loss which they have sustained. In moving the resolution Mr. Piers gave an account of the life and eminent services of the deceased gentleman. It was reported that

Miss Margaret D. Webster, B.Sc., had been elected a student member Jan. 2. Copies of the printed Proceedings, Vol 18, pt. 3, 1932-33, were laid on the table. Dr. S. G. Ritchie presented a paper on "The Determination of the Initial and Final Sets of Plaster-of-Paris;" and Stuart Johnston, B.Sc., one on "A Microscopical Study of Polished Surfaces of Explosive Antimony."

4th Meeting, Feb. 12, 1934.—It was announced that Miss Margaret Butler, Ph.D., had been elected an ordinary member Jan. 29. Papers were presented by A. L. Geddes, on "The Decomposition of Complex Molecules at High Pressures;" and by Dr. N. B. Dreyer and Miss D. Webster on "Effects of Arterial and Venous Occlusion on the Intestine."

5th Meeting, Mar. 12, 1934.—It was announced that Prof. A. C. Cuthbertson, Ph.D., Sackville, N.B., had been elected an associate member Feb. 26. Papers were presented by Prof. C. W. Startup on "The Effect of Insulin on the Metabolism of Heart Muscle;" by Donald M. Ross on "Monstrosities in Salmon Embryos;" and by Dr. A. H. Leim on "Water Temperatures in Grand Lake, N. S."

6th Meeting, Apr. 9, 1934.—Owing to Dr. Leim's transfer to St. Andrews, N. B., the chair was occupied by the first vice-president, Dr. Henderson. Papers were presented by Norman B. Gillies on "A Lunar Phenomenon on the Night of Feb. 25, 1934;" by Miss H. R. Belyea and Miss W. Scott on "The Conditions of Sedimentation of the Halifax Formation as Observed in Point Pleasant Park;" by R. L. Milner "On the Solubility of Gold in Ferric Sulphate;" and by Prof. G. V. Douglas and C. K. Howse "On the Location of Ore Shoots in Mineral Deposits."

7th Meeting, May 7, 1934.—Papers were presented by Prof. H. S. King on "Fractional Distillation: Analysis of Organic Liquids;" by the same gentleman and Miss Mary K. Merriam on "Preparation of m-Xylyl Chloride;" by J. R. Longard and Prof. J. H. L. Johnstone on "An Improved Bridge for the Measurement of Small Capacities, and Some Preliminary Measurements of the Variation of Dielectric Constant of

Rutile with Temperature;" by W. A. Crandall on "The Relation of Arginine and Histidine to the Synthesis of Purines in the Dog;" and by Prof. A. F. Chaisson of Antigonish and M. H. Friedman of Montreal on "The Effect of Histamine, Adrenaline and Destruction of the Spinal Chord on the Osmotic Pressure of the Blood in the Skate."

HARRY PIERS,
Recording Secretary.

ABSTRACTS.

(Papers read before the Institute but not published in the Proceedings).

THE METABOLISM OF DEVELOPING *Cyclopterus Lumpus* EGGS. Frederick Ronald Hayes, Dept of Zoology, Dalhousie Univ., Halifax, N. S. (Read Nov. 13, 1933). Determinations of the water, protein, fat and ash contents of the developing eggs of the common lump-sucker, Cyclopterus lumpus, have been made. The results suggest that the following periods in egg development exist: (a) from fertilization to the 6th day, characterized by decreased water and increased fat and protein (up to the late embryonic shield stage); (b) from the 6th to the 10th day, showing increasing water and decreasing fat and protein (up to the stage of rudimentary unpigmented eyes); (c) from the 10th day onwards (to the time when the yolk sac is completely absorbed), showing increasing water and fat and decreasing protein. The ash content did not change significantly during the period investigated.

A NEW METHOD OF DETERMINING THE AGE OF MINERALS. G. H. Henderson, Dept. of Physics, Dalhousie Univ., Halifax, N. S. (Read Nov. 13, 1933). The effect of the actinium series in pleochroic haloes of the uranium type was discussed and shown to lead to a new method of finding the age of the mineral bearing the haloes. Application of the method was made to three biotites which have been studied in detail. (Published in full in Proc. Roy. Soc. A. **145**, 591-8 (1934)

THE CYTOLOGY OF CERTAIN CULTIVATED APPLES. Muriel V. Roscoe, Dept. of Biology, Acadia Univ., Wolfville, N. S. (Read Dec. 11, 1933). Some eighteen varieties of apples grown in the Annapolis Valley have been studied cytologically. Fourteen varieties have been found to be diploid and four triploid. Regularity of chromosomal action is characteristic of diploids in contrast with the irregularity of action on the part of triploids. Homology and a balanced relationship of the chromosomes, rather than environmental factors, explain the normal reduction figures of the diploid varieties. The application of the findings to problems of the breeder and the grower is pointed out.

CULTURAL CHARACTERISTICS OF MARINE BACTERIA IN RELATION TO LOW TEMPERATURES. Ernest Hess, Fisheries Exp. Sta. (Atlantic), Halifax, N. S. (Read Dec. 11, 1933). Growth and normal pigment formation of Pseudomonas fluorescens and Flavobacterium deciduosum (isolated from cod fish slime) on nutrient agar have been observed at 0°C, -3°C and -6.5°C.

Ps. *fluorescens* maintained motility at these temperatures for over five weeks. i.e., longer than at temperatures above O°C. Practically all cultural characteristics of these organisms and *Achromobacter* x were evident at -3°C. Nitrate reduction, proteolysis of fish muscle protein and fluorescence on fish extract agar were the least cold-sensitive of the reactions, becoming evident at -3°C in as short periods as 5, 7 and 12 days, respectively. These temperatures are the lowest recorded in the literature at which evidence of normal cultural characteristics have been observed for any bacteria. Prolonged cultivation of the test-organisms at 5°C. produced "adapted" strains that were more active at O°C. and especially at -3°C., than strains sub-cultured at 20°C., O°C or -3°C. With few exceptions, no "adaptation" to cultivation at O°C. or -3°C. occurred.

A MICROSCOPICAL STUDY OF POLISHED SURFACES OF EXPLOSIVE ANTIMONY. Stuart Johnston, Dept. of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Jan. 15, 1934). The explosive crystallization of amorphous antimony is revealed by the microscope as a spherical wave travelling through the metal. Various aspects of the phenomenon as well as attempts to measure the velocity of the explosive wave are discussed.

THE DECOMPOSITION OF COMPLEX MOLECULES AT HIGH PRESSURES. A. L. Geddes, Dept of Chemistry, Dalhousie Univ., Halifax, N. S. (Read Feb. 12, 1934). The decomposition velocity of gaseous paraldehyde has been found to diminish with increase of pressure. This effect is predicted to be general and is attributed to a relatively slow interchange of energy between different parts of the molecule.

EFFECTS OF ARTERIAL AND VENOUS OCCLUSION ON THE INTESTINE. N. B. Dreyer and Dorothy Webster, Dept. of Pharmacology, Dalhousie Univ., Halifax, N. S. * (Read Feb. 12, 1934). Arterial occlusion for periods up to 30 minutes does not interfere with intestinal recovery. The immediate response is a short stimulation followed by dilatation. Venous occlusion for five to ten minutes leaves no bad after effects. For periods of twenty to thirty minutes, exudation into the intestine takes place and an increase in mobility.

THE EFFECT OF INSULIN ON THE METABOLISM OF HEART MUSCLE. C. W. Startup, Dept. of Physiology, Dalhousie Univ., Halifax, N. S. (Read Mar. 12, 1934). It is shown that when there is an adequate supply of sugar in the blood the energy requirements of the heart are met by carbohydrates. When the blood sugar is used up, the heart apparently falls back on fat rather than protein for its energy. It seems possible that protein may form a transitory stage in the change over from carbohydrate to fat.

DESCRIPTION OF A LUNAR PHENOMENON ON THE NIGHT OF FEB. 25, 1934. Norman B. Gillies, Dept of Geology, Dalhousie Univ., Halifax, N. S.(Read April 9, 1934). This paper describes four rings which appeared around the moon on the night of Feb. 25, 1934, three of which are considered to be very unusual.

NOTE ON THE LOCATION OF ORE-SHOOTS IN MINERAL DEPOSITS. G. V. Douglas and C. K. Howse, Dept. of Geology, Dalhousie Univ.,Halifax, N. S. (Read April 9, 1934) Ore-shoots can be defined as those portions of a mineralized zone which have sufficient concentrations of the valuable minerals to make them workable. Ore-deposits of hypogene hydrothermal origin can be classified in terms of ore-shoots: A. deposits in which the whole of the mineralized zone is ore; B. deposits in which the ore-shoots are governed by geological structure; C. deposits in which the chemical character of the wall rock control mineralization: D. deposits in which there is no visible structural or chemical control. The experiments are based on two tentative assumptions: (1) the zoning of minerals represents the precipitation from a more or less continuous solution which is carrying away from the cooling magma various solutes which have been given off in this order; (2) ore-shoots represent the channelways which are open at the time when these solutions are given off from the magma. (The full paper appears in the Bull. Can. Inst. Min. & Met., 1934).

AN IMPROVED BRIDGE FOR THE MEASUREMENT OF SMALL CAPACITIES AND SOME PRELIMINARY MEASUREMENTS OF THE VARIATION OF DIELECTRIC CONSTANT OF RUTILE WITH TEMPERATURE. J. R. Longard and J. H. L. Johnstone, Dept of Physics, Dalhousie Univ., Halifax, N. S. (Read May 7, 1934). To measure the temperature variations of the dielectric constant of rutile at a ferquency of 1,000 cycles per second, a Hartshorn-Schering bridge was used, modified (1), by having a standard variable air condenser connected in parallel with a large fixed condenser as the variable and (2), by the addition of a Wagner ground system. By this method an amplification factor of 400 was obtained, i.e., a change in capacity of 1 micromicrofarad in the test condenser was represented by a change of 400 micromicrofarads in the standard condenser, so that differences in capacity up to 3 micromicrofarads could be measured to a relative accuracy of .001 micromicrofarad. To obtain the required signal strength from the microphone hummer for settings of this accuracy, a four stage audio amplifier was connected to the output of the bridge. In the parallel plate test condenser used the distance between the plates was found from the dfferences in capacity when the separation of the plates was changed by a measured distance. Some preliminary values of the change in dielectric constant from room temperature to 115° C. of rutile, cut perpendicular and parallel to the optical axis, are given.

THE RELATION OF ARGININE AND HISTIDINE TO THE SYNTHESIS OF PURINES IN THE DOG. W. A. Crandall, Dept. of Biochemistry, Dalhousie Univ., Halifax, N. S. (Read May 7, 1934). The effects on purine metabolism of diets high in histidine and high in arginine are compared by their effects on the excretion of uric acid and allantoin. Diets high in histidine gave increased uric acid varying from 36% to 267%, and allantoin varying from 22.8% to 105% over the control diet. Diets high in arginine but low in histidine gave decreased excretion of uric acid and allantoin varying from 2 to 95% and 0 to 56% respectively. That these changes are not due to changes into the endogenous metabolism generally is shown by a study of the amounts of creatonine excreted. The results are interpreted to indicate an increased synthesis of purines on the high-histidine diet, pointing to histidine as the precursor of the purine nucleus.

APPENDIX

LIST OF MEMBERS

PATRON

His Honour W. H. Covert, K.C., Lieutenant-Governor of Nova Scotia.

ORDINARY MEMBERS	*Date of Election*
Babkin, B.P.,M.D.,D.Sc.,F.R.S.C., McGill University, Montreal, P. Q.	26 Feb., 1925
Bagnall, J. Stanley, D.D.S.,F.A.A.R.D., Dalhousie Univ., Halifax, N. S.	27 Nov., 1933
Baxendale, Herbert, Imperial Cable Co., Dennis Building, Halifax, N. S.	7 Jan., 1935
Bean, R. J., M.S., Dalhousie University, Halifax, N. S.	4 Dec., 1923
Beatty, S. A., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	4 Nov., 1929
Bell, H. P., M.Sc.,Ph.D., Dalhousie University, Halifax	1 Dec., 1920
Borrett, Major W. C., C.H.N.S., Lord Nelson Hotel, Halifax	26 Feb., 1925
*Bronson, H. L., Ph.D.,F.R.S.C., Dalhousie University, Halifax	9 Mar., 1911
Burbidge, G. A., Dalhousie University, Halifax	7 Feb., 1927
Butler, Margaret R., M.Sc.,Ph.D., Dalhousie University, Halifax	29 Jan., 1934
*Cameron, John, M.D.,D.Sc.,F.R.S.S.E&C., "Wingfield" 5 Grosvenor Gardens, Golders Green, London, N. W. II, England	2 Nov., 1915
*Chipman, H. Ritchie, Ph.D., Fisheries Experimental Station (Atlantic) Halifax	3 Oct., 1921
Coffin, C. C., M.Sc.,Ph.D., Dalhousie University, Halifax	3 Nov., 1930
*Colpitt, Parker R., 34 Coburg Rd., Halifax	2 Feb., 1903
Cooper, D. LeB., Ph.D., Fisheries Experimental Station (Atlantic), Halifax.	9 Nov., 1927
Copp, W. P., B.Sc.,M.E.I.C., Dalhousie University, Halifax	28 Apr., 1921
Cornelia, Rev. Bro. W. S., St. Mary's College, Halifax	1 Oct., 1925
Creighton, H. J. M., M.A.,M.Sc.,D.Sc.,F.C.S., Swarthmore College, Swarthmore, Penn., U. S. A.	7 Jan., 1908
Cruickshank, E. W. H., M.D.,D.Sc.,Ph.D.,M.R.C.P.,F.R.S., Dalhousie University, Halifax	4 Mar., 1929
Cunningham, Allan R., M.D.,C.M.,F.A.C.S., 260 Barrington St., Halifax	1 Dec., 1921
*Davis, C. H., C.E., Bass River, Cape Cod, Mass., U. S. A.	5 Dec., 1900
*Doane, F. W. W., C.E., Young Ave., Halifax	3 Nov., 1886
Douglas, G. V., M.Sc.,F.G.S., Dalhousie University, Halifax	31 Oct., 1932
Dreyer, N. B., M.A.,M.R.C.S.,L.R.C.P., Dalhousie University, Halifax	3 Nov., 1930
Duchemin, Warren J., B.A., Prince of Wales College, Charlottetown, P. E. I.	2 Dec., 1929
Edwards, G. A., M.I.R.E., 79¼ Lawrence St., Halifax	7 Jan., 1929
Fraser, Roy H., M.Sc., Bloomfield High School, Halifax	24 Nov., 1930
Hayes, F. Ronald, M.Sc., Ph.D., Dalhousie University, Halifax	24 Nov., 1930
*Henderson, G. H., M.A.,Ph.D.,F.R.S.C., Dalhousie University, Halifax	2 Nov., 1915
Hess, Ernest, M.A.,Ph.D., Fisheries Experimental Station (Atlantic), Halifax	9 Nov., 1927
Huntsman, A. G., B.A.M.B. University of Toronto, Toronto, Ont.	7 Feb., 1927
Jacobson, M., M.D.,C.M., 22 Gottingen St., Halifax	26 Oct., 1931
Johnston, W. W., Ph.D., Fisheries Experimental Station (Atlantic), Halifax.	27 Nov., 1933
*Johnstone, J. H. L., M.Sc.,Ph.D., Dalhousie University, Halifax	2 Dec., 1912
King, Harold S., Ph.D., Dalhousie University, Halifax	30 Nov., 1922
King, Mrs. Harold S., M.A., Armdale, Halifax	30 Nov., 1922
Leim, A. H., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	9 Nov., 1927
Linton, E. P., Ph.D., Fisheries Experimental Station (Atlantic), Halifax	5 Nov., 1934
Mader, Victor O., M.D.,C.M., 149 South St., Halifax	7 Feb., 1927
Mainland, Donald R., M.B.,Ch.B.,D.Sc., Dalhousie University, Halifax	3 Nov., 1929
Matheson, D. J., B.Sc., Halifax County Academy, Halifax	2 Nov., 1915
Mellish, Hon. Mr. Justice, 31 Hollis St., Halifax	25 Jan., 1932
Mitchell, Capt. W. F., Customs House, Halifax	5 Dec., 1927
Moreash, Roy, M.D.,C.M., Berwick, N. S.	26 Oct., 1931
MacFarlane, A. S., B.S.A., Fisheries Experimental Station (Atlantic), Halifax	3 Feb., 1930
McInnes, Hector, LL.B.,K.C., Bedford Row, Halifax	27 Nov., 1889
*MacKay, G. M. J., M.A.,M.Sc., American Cyanamid Co., New York, N. Y., U. S. A.	28 Dec., 1903
*MacKenzie, A. Stanley, Ph.D.,D.C.L.,LL.D.,F.R.S.C., 25 Kent St., Halifax	7 Nov., 1905
MacKenzie, D. J., M.D.,C.M., Pathological Institute, Halifax	7 Feb., 1927
*Nicholls, A. G., M.D.,D.Sc.,F.R.S.C., The Laurentian Apartments, 29 Cote des Neiges Road, Montreal, P. Q.	2 Nov., 1915
Nickerson, C. B., A.M., Dalhousie University, Halifax	9 Mar., 1911
Nickerson, J. L., M.A.,Ph.D., Mt. Allison University, Sackville ,N. B.	7 Feb., 1927

*Life Member.

	Date of Election
Pelluet, Dixie, B.Sc., M.A.,Ph.D., Dalhousie University, Halifax	4 Jan., 1932
Piers, Harry, Curator Provincial Museum, Nova Scotia Technical College, Halifax	2 Nov., 1888
*Ritchie, S. G., B.A.,D.M.D., 36 South St., Halifax	3 Oct., 1918
*Robb, D. W., Amherst	4 Mar., 1890
Sexton, F. H., B.Sc.,D.Sc., Nova Scotia Technical College, Halifax	18 Dec., 1903
Smith, H. W., B.Sc., Truro	6 Jan., 1890
Todd, E. W., B.A., Dalhousie University, Halifax	27 Nov., 1919
Whyte, E. F., M.A.,Ph.D., 5 McDonald St., Halifax	1 Dec., 1920
*Winfield, J. H., Maritime Tel. & Tel. Co., Halifax	2 Dec., 1903
*Woodbury, W. W., B.Sc.,D.D.S., 70 Spring Garden Road, Halifax	30 Nov. 1916
*Yorston, W. G., C.E., Queen St., Truro, N. S.	12 Nov., 1892
Young, E. G., M.Sc.,Ph.D., Dalhousie University, Halifax	26 Feb., 1925
Vladykov, V. D., Ph.D., Fisheries Experimental Station (Atlantic), Halifax.	5 Nov., 1934

ASSOCIATE MEMBERS

*Bayne, P. M., M.A., Acadia University, Wolfville	28 Mar., 1928
*Bigelow, H. B., Ph.D., Harvard University, Cambridge, Mass., U. S. A.	7 Jan., 1929
Bigelow, H. E., Ph.D., Mt. Allison University, Sackville, N. B	3 Dec., 1928
*Churchill. F. C., 15 Newton St., Sherbrooke, P. Q	3 Apr., 1919
*Connolly, C. J., Ph.D., Catholic University, Washington, D. C	5 Nov., 1911
Harlow, L. C., B.S.A., College of Agriculture, Truro, N. S	23 Mar., 1905
Hatcher, A. G., M.A., Memorial College, St. John's, Nfld	9 Dec., 1914
Hill, D. U., Ph.D., Acadia University, Wolfville, N. S	7 Jan., 1929
Munro, Lloyd A., Ph.D., University of Manitoba, Winnipeg, Man	1 Nov., 1922
*MacKay, Hector H., M.D., New Glasgow, N. S	4 Feb., 1902
Roscoe, Muriel V., Ph.D., Acadia University, Wolfville, N. S	7 Jan., 1929
Smith, M. W., M.A.,Ph.D., Atlantic Biological Station, St. Andrews, N. B.	25 Feb., 1935
Tufts, R. W., Wolfville, N. S	3 Oct., 1921

CORRESPONDING MEMBERS

Cox, Philip B., B.Sc., Ph.D., Fredericton, N. B	3 Dec., 1902
Faribault, E. R., B.A.,D.Sc.,F.R.S.C., Ottawa, Ont	6 Mar., 1888
Fraser-Harris, D. F., M.B.,C.M.,M.D.,B.Sc.,D.Sc.,F.R.S.E.,F.R.S.C.,L.M. C.C., The Author's Club, London S. W., England	29 Feb., 1912
Ganong, W. F., Ph.D., Smith College, Northampton Mass., U. S. A	6 Jan., 1890
Gates, R. R., Ph.D.,LL.D.,F.R.S., Kings College, University of London, London, W. C., England	30 Nov., 1916
Matheson, Robert, Ph.D., Cornell University, Ithaca, N. Y., U. S. A	30 Nov., 1916
McIntosh, Douglas, D.Sc.,F.R.S.C., Shawinigan Chemicals Ltd., Shawinigan Falls, P. Q	4 Dec., 1923
Prince, E. E., D.Sc.,LL.D., Ottawa, Ont	5 Jan., 1897

STUDENT MEMBERS

Begg, R. W., 98 Inglis St., Halifax	7 Jan., 1935
Belyea, Helen R., B.Sc., Dalhousie University, Halifax	5 Nov., 1934
Parker, W. Ernest, Dalhousie University, Halifax	7 Jan., 1935
Mushkat, Carl M., M.Sc., University of Toronto, Toronto, Ont	29 Dec., 1930
Ross, D. M., B.A., Dalhousie University, Halifax	5 Nov., 1934
Wilson, A. J. C., B.Sc., Kings College, Halifax	26 Nov., 1934

*Life Member.

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

Hon. Philip Carteret Hill, D.C.L	31 Dec., 1862	to	26 Oct., 1863
John Matthew Jones, F.L.S.,F.R.S.C	26 Oct., 1863	"	8 Oct., 1873
John Bernard Gilpin, M.A.,M.D.,M.R.C.S	9 Oct., 1873	"	9 Oct., 1878
William Gossip	9 Oct., 1878	"	12 Oct., 1880
John Somers, M.D	12 Oct., 1880	"	26 Oct., 1883
Robert Morrow	26 Oct., 1883	"	21 Oct., 1885
John Somers, M.D	21 Oct., 1885	"	10 Oct., 1888
Prof. James Gordon MacGregor, M.A.,D.Sc.,F.R.S.,F.R.S.C.	10 Oct., 1888	"	9 Nov., 1891
Martin Murphy, C. E., D.Sc.,I.S.O	9 Nov., 1891	"	8 Nov., 1893
Prof. George Lawson, Ph.D.,LL.D.,F.I.C.,F.R.S.C	8 Nov., 1893	"	10 Nov., 1895
Edwin Gilpin, Jr., M.A.,LL.D.,D.Sc.,F.G.S.,F.R.S.C.,I.S.O.	18 Nov., 1895	"	8 Nov., 1897
Alexander McKay, M.A	8 Nov., 1897	"	20 Nov., 1899
Alexander Howard MacKay, B.A.,B.Sc.,LL.D.,F.R.S.C	20 Nov., 1899	"	24 Nov., 1902
Henry Skeffington Poole, M.A.,D.Sc.,A.R.S.M.,F.G.S., F.R.S.C	24 Nov., 1902	"	18 Oct., 1905
Francis William Whitney Doane, C.E	18 Oct., 1905	"	11 Nov., 1907
Prof. Ebenezer Mackay, Ph.D	11 Nov., 1907	"	12 Dec., 1910
Watson Lenley Bishop	12 Dec., 1910	"	11 Nov., 1912
Donald MacEachern Fergusson, F.C.S	11 Nov., 1912	"	12 Oct., 1915
Prof. David Fraser Harris, M.B.,C.M.,M.D.,B.Sc.,D.Sc., (London)F.R.SS.E.&C	13 Oct., 1915	"	18 Nov., 1918
Prof. Howard Logan Bronson, Ph.D.,F.R.S.C	18 Nov., 1918	"	8 Nov., 1920
Prof. John Cameron, M.D.,D.Sc.,F.R.SS.E&C	8 Nov., 1920	"	20 Nov., 1922
Prof. Carleton Bell Nickerson, M.A	20 Nov., 1922	"	12 Nov., 1924
Stephen Galway Ritchie, B.A.,D.M.D	12 Nov., 1924	"	12 Oct., 1926
Prof. John Hamilton Lane Johnstone, M.Sc.,Ph.D.,M.B.E.	13 Oct., 1926	"	10 Oct., 1928
Prof. Douglas McIntosh, Ph.D.,F.R.S.C	10 Oct., 1928	"	15 Oct., 1930
Prof. E. G. Young, Ph.D	15 Oct., 1930	"	12 Oct., 1932
Prof. A. H. Leim, Ph.D	12 Oct., 1932	"	10 Oct., 1934

The foundation of the Halifax Mechanics' Institute on 27th December, 1831, and of the Nova Scotian Literary and Scientific Society about 1859 (the latter published its transactions from 4th January to 3rd December, 1859) led up to the establishment of the Nova Scotian Institute of Natural Science in December, 1862.

Note.—The first general meeting of the Nova Scotian Institute of Natural Science was held at Halifax, on 31st December, 1862. On 4th March, 1890, the name of the Society was changed to the Nova Scotian Institute of Science, and it was incorporated by an act of the legislature in the same year.

Since 1879 the Presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

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